

**ENERGY AND MINERAL RESOURCES OF THE FREMONT BLOCK,
EMERY AND SEVIER COUNTIES, UTAH**

by

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EXECUTIVE SUMMARY

The Fremont block consists of 5426.4 contiguous acres of state-owned surface and mineral estate in southwest Emery County and northeast Sevier County. The block is readily accessible via SR-10 and I-70. The nearest rail access is in Price, about 60 miles north of the block. Efforts are underway to bring rail access to Salina about 38 miles west of the property.

The block lies on the gently west-dipping flank of the San Rafael Swell near the base of the Wasatch Plateau. The climate is arid and there are no perennial streams or natural water impoundments on the property. The block is situated near the middle of the southern Emery coalfield which contains over 2.4 billion tons of available coal resources. The only structural feature in the area is the Joes Valley graben, which at its nearest point, is about 1 ¼ miles west of the block.

The surface is being used for grazing and the Utah Department of Transportation (UDOT) has a material permit for sand and gravel on a portion of the block near I-70. Part of the block is under lease for oil, gas, and other hydrocarbons, and another part of the block is under lease for clay minerals. Neither of these leases are being pursued for development.

Coal mining has a long history in Emery County, dating back to 1881. Coal was produced from the south east part of the Fremont block almost continuously from the 1930s to 1980 in the Dog Valley area, producing over 700,000 tons of coal. Just north of the block, the Emery mine and its

predecessor, the Browning mine have collectively produced about 8.7 million tons of coal. The Emery mine, which was re-activated in 2002, was idled in August 2003, and is for sale.

The Fremont block contains 89.8 million tons of available deep coal resources and 3.1 million tons of available surface coal resources for a total available resource of 92.9 million tons. Ninety seven percent of these resources are contained in the A, CD, I, and L beds that lie at depths less than 1000 feet. The coals within the Fremont block vary substantially in thickness and quality from bed to bed. Based on a combination of ash and sulfur values, the higher quality coals are in the A and I beds, which contain 48.7 and 24.0 million tons respectively.

The development potential for the Fremont block is favorable although direct access to the available deep coal resources from outcrop appears to be limited. Additional study is required to delineate suitable entry sites and further define the mineability of the coal resource.

In addition to coal, the Fremont block contains a substantial resource of sand and gravel in alluvial sediments. Other potential resources include humate, coalbed methane, and deep oil and gas.

INTRODUCTION

Location

The Fremont block is located in the southwest corner of Emery County and northeast Sevier County and consists of an eight-section block of contiguous land. The block lies approximately eight miles south of the town of Emery, and is easily accessed via State Highway 10 (SR-10) and Interstate Highway 70 (I-70) (**plate 1**). Salina is 38 miles west of the block, and Green River is 65 miles east of the block. Price, the hub of the Carbon-Emery area and Utah's coal industry, is about 63 miles north of the block. The block is located within the southern Emery coalfield that contains significant coal and coalbed methane resources.

Background

The evaluation of the Fremont block in Emery County is part of the Utah Geological Survey's (UGS) ongoing geologic evaluation of the mineral potential of state-owned lands managed by the Utah School and Institutional Trust Lands Administration (SITLA). The UGS has long cooperated with SITLA on developing Utah's energy and mineral resources. During the last 3 ½ years the UGS has pursued a systematic evaluation of mineral resources on SITLA land. The section-by-section evaluation phase of the project was completed in fall 2003. The evaluation for Emery County reported on 776 blocks representing 335,085 acres of state-owned land.

The current phase of the project consists of county, commodity, and large, land-block evaluations. The Fremont block is the first of SITLA's large land blocks to be evaluated in detail.

Purpose and Scope

The purpose of the Fremont block project is to compile all known information on the economic geology into a report with attached maps and associated GIS data. The data have been interpreted and integrated into a discussion of resources, past production, and economic potential with recommendations for mineral development.

Methods

This study includes a compilation of mineral and geologic data from the UGS's Utah Mineral Occurrence System (UMOS) files and from other UGS published and unpublished sources. The coal resource evaluation for the southern Emery coalfield and the Fremont block was completed in GIS format using the Spatial Analyst extension in ArcView and includes over 4400 data points from the UGS's coal data bank. The discussion on industrial minerals, base and precious metals, and oil and gas was extracted from UGS Bulletin 132 (**Gloyn and others, 2003**) updated where needed.

Additional Resource Information

UGS Bulletin 132, "Energy, mineral, and ground-water resources of Carbon and Emery Counties, Utah, (Gloyn and others, 2003) is an excellent summary on the energy and mineral resources of the

area. The UGS also prepares an annual mineral activity summary for the state, and summaries for the years 1996 through 2003 are available on the Survey's web site at URL

<<http://www.geology.utah.gov/utahgeo/energy/index.htm>>.

The Utah Energy Office prepares an annual coal report that summarizes the production, distribution, and utilization of coal mined in Utah. Reports for the years 1998 through 2002 are available on the Energy Office's web site at URL< <http://www.energy.utah.gov/edis.htm#coal>>.

UGS Special Study 112 titled “ The available coal resource for eight 7.5-minute quadrangles in the southern Emery coalfield, Emery and Sevier Counties, Utah” by Quick and others is in press. That study is the basis for the coal resource evaluation for the Fremont block.

Mining History

Coal is believed to be the first mineral commodity mined in the Carbon-Emery area and mines were developed as early as 1881 (**Spieker, 1931**). The development of industrial minerals, oil, gas, and uranium/vanadium followed, as the population grew, markets for additional mineral products were created, and new technologies lead to their discovery and development. In recent years, the development of coal bed methane resources has become an important asset in the economic well being of Carbon and Emery Counties.

At the present time there are no minerals being extract from the Fremont block. Previously, coal and at times sand and gravel have been extracted (**plate 2, table 1**). As shown in the table, most of the mine permits are for humic shale. Six humic shale mine permits are listed as active, but only three mines reported production for 2003 (DOGM file data as of May 20, 2004). The Rockland

Mine, Permit ID M150040, is operating under a Small Mine permit, but has applied for a Large Mine permit to expand its operation. That permit has not been approved. The only recently active coal operation in the southern Emery coalfield, the Emery mine, was idled in August 2003, and the permit is listed as inactive.

Block Development History

Agriculture, mining, and coalbed gas production are the three main industries in the area. The surface of the block is currently used for livestock grazing. While both coal and sand and gravel have been produced from the block, coal is by far the most important product. Since 1980, coal production from the Emery coalfield has been sporadic largely due to distance to rail transportation. In 2002, 25.3 million tons of coal were produced in Utah; 46.2 % or 11.7 million tons were produced in Emery County and 30 % or 7.6 million tons were produced in Sevier County (**Utah Energy Office, 2003**). While only a small portion of that production came from the Emery coalfield (26,000 tons in 2002) (UGS field data), a significant resource remains available for mining. Some of the historical coal production in the Emery coalfield came from the Fremont block. Sand and gravel have been mined in the region and from the Fremont block for road construction and maintenance.

The coals and associated sands of the northern and central parts of the Emery coalfield are being vigorously developed for coalbed gas. The development began in the Drunkard's Wash area south of Price in 1993 and is expanding continuously. The coals in the southern part of the Emery coalfield are relatively shallow and lower in methane content than those coals to the north making

them less attractive, but increased fuel prices and technological developments may allow future development in the southern part of the field.

Block Description

The Fremont block consists of all of the following sections of land for a total of 5426.4 acres.

Township 23 South, Range 5 East, Salt Lake Base Line and Meridian

Sections 24, (640 acres), 25 (640 acres), and 36 (640 acres);

Township 23 South, Range 6 East, Salt Lake Base Line and Meridian

Sections 19 (682.04 acres), 30 (664.96 acres), 31 (662.84 acres), and 32 (640 acres); and

Township 24 South, Range 5 East, Salt Lake Base Line and Meridian

Section 2 (856.56 acres).

Surface and Mineral Use

The Fremont block is subject to grazing permits, mineral leases for oil, gas, and hydrocarbons, clay, and material permits for the extraction of sand and gravel (**table 2, figure 1**). Two grazing permits, GP 21725 and GP 22841, cover the entire block and are held Johnson Livestock Oak Ranch. These permits will expire in 2006 and 2016 respectively. The oil, gas, and hydrocarbon lease, ML 46572, is held by Chevron USA, Inc. and will expire May 31, 2004. Mineral leases ML

48506 and 48507 are clay leases held by Wayne Hunt and will expire in July 2008. The material permit, MP 290, is held by UDOT and expires in 2008.

A Right of Entry application to conduct seismic testing on the Fremont block was submitted by Shamrock Mining Company, Provo, Utah on April 20, 2004, and is yet to be issued.

Accessibility

The regional map (plate 1) shows locations of major highways and access roads; rail lines and coal load outs; high-voltage transmission lines; major natural gas gathering lines; Emery coalfield and southern Emery coalfield study area; and oil, gas, and CO₂ fields.

Roads and Highways

The block is accessible by several unimproved roads that extend eastward across the block from SR-10, which runs south from Price to the intersection of I-70, a distance of about 66 miles. The block is also accessible from I-70, which crosses the block in a northeast-southwest direction. A partially maintained road provides access to the Dog Valley mine area in the southeast part of the block.

Rail

The nearest rail access is the CV spur near Price, a distance of approximately 60 miles. A former rail load out site exists east of Green River, a distance of about 65 miles. The nearest rail load out

to the west is at Levan, a distance of 83 miles. A study is currently underway by the Six County Association of Governments to extend the rail from near Levan to Salina. This extension would shorten the truck haul distance from the Fremont block to 39 miles. The U.S. Surface and Transportation Board's Section of Environmental Analysis is in the process of drafting a final Scope of Analysis for an Environmental Impact Statement (EIS). Additional information regarding the proposed rail line can be found online at <http://www.trainweb.org/utahrails/rr/prr/sl.html>. Baseline data for the EIS is being collected and completion is anticipated in the fall or early winter of 2004 (Malcom Nash, Six County Association of Governments, personal communication, May 2004). A rail line to the former Emery Deep mine was laid out in the late 1970s and has been re-evaluated several times, but is not being actively pursued.

High-Voltage Power and Gas Transmission Lines

A twin, 345-kilovolt transmission line from the Hunter power plant east of Castle Dale runs parallel to and west of SR-10. At its closest point, the line is about 2 miles from the block. The nearest natural gas gathering line is a 20-inch diameter line operated by Questar Pipeline Company that runs north from the Ferron field to the Drunkards Wash area south of Price. The Ferron field lies about 20 miles north of the block. Natural gas service extends only as far south as the town of Ferron (Karen Tobey, Questar, Inc., personal communication, May 18, 2004).

GEOLOGIC SETTING

The terrain is relatively flat-lying with elevations generally in the range of 6200 to 6600 feet. The only significant drainage is Dog Valley Wash located in the southeast part of the block (plate 3).

The block contains significant mineable coal resources of the southern Emery coalfield and the southeast part of the block was mined almost continuously from 1930 to 1980 (**Quick and others, in press**). The coal beds in the Emery coalfield are in the 300- to 800-foot-thick Upper Cretaceous Ferron Sandstone Member of the Mancos Shale (**Doelling, 1972**). Dips of the coal-bearing strata are usually between two and four degrees to the north-northeast (Quick and others, in press). Coal outcrops are generally located east of the block, but outcrops from the upper coal horizons crop out along the east side of section 30, T. 23 S., R. 6 E., and extend southward through most of sections 31 and 32, T. 23 S., R. 6 E. (plate 3). Outcrops of the lower coal horizons are east of the upper coal horizons, but do outcrop in the southeast corner of section 32, T. 23 S., R. 6 E.

Structure and Faulting

The block lies on the gently dipping west slope of the San Rafael Swell. The major structural feature in the block area is the northeast-southwest-trending Joes Valley graben (plate 2). The graben is about one mile wide with over 1000 feet of displacement in the area south of Emery. The graben runs roughly parallel to SR-10 in this area and is about one mile west of the block (Quick and others, in press). The graben continues in a southerly direction through the south end of the Emery coalfield. Numerous faults have been mapped on either side of the graben, but none are shown to extend onto the Fremont block.

Geology of the Mancos Shale

The Mancos Shale is the dominant stratigraphic unit in the area and is exposed from the base of the cliffs of the Wasatch Plateau eastward several miles to the base of the Coal Cliffs escarpment where underlying units of the Cretaceous Dakota Sandstone and Cedar Mountain Formation are exposed. The Mancos consists of the following five members (in ascending order): (1) Tununk Shale Member (500-800 feet thick), (2) Ferron Sandstone Member (300-800 feet thick), (3) Lower Blue Gate Shale Member (1500-2000 feet thick), (4) Emery Sandstone Member (500-1000 feet thick), and (5) the Upper Blue Gate Shale Member (300-1000 feet thick) (Quick and others, in press). Only the Ferron Sandstone and the Lower Blue Gate Shale are exposed on the Fremont block.

Geology of the Ferron Sandstone

Chidsey (2002) describes The Ferron Sandstone

as an eastward thinning clastic wedge deposited during Turonian-Coniacian (Upper Cretaceous) time. Lower and upper parts of the Ferron are distinguished. The Lower Ferron consists, on outcrop, of shelf sandstones that were transported generally from north to south; the Upper Ferron consists of deltaic deposits that prograded from southwest to northeast. Eight correlatable and mappable units, designated Kf-1 through Kf-8, are recognized in the Upper Ferron. Each unit records a transgressive-regressive cycle of sedimentation (**figure 2**). The Clawson

and Washboard units, which constitute the Lower Ferron, are shelf sandstones that drifted southward along the hinge of the foreland basin, sourced from the shoreline in the vicinity of the present-day Book Cliffs.

Ryer (1981) recognized that “the Upper Ferron consists of a series of stacked, deltaic units that can be defined in outcrop on the basis of cliff-forming delta-front sandstone bodies. These [units] record transgressive-regressive cycles of sedimentation.” Five major, correlatable, sandy delta-front units, Kf-1 through 5 in ascending order, plus three less-widespread delta-front sandstones, later designated Kf-6, Kf-7, and Kf-8 were mapped. Each delta-front unit, with the exception of Kf-8, was found to have an associated coal bed. The coals carry letter designations originally assigned to them by Lupton (1916).

Coal Occurrences in the Ferron Sandstone

Coal in the Ferron Sandstone is distributed from the lower third of the member upward to the top. Lupton (1916) grouped the coal into 13 beds lettered A to M in ascending order. These beds are not present everywhere in the Emery coalfield. The lower group of coal beds, A to E, generally cluster within a 75-foot interval, followed by a mostly barren 75-to 150-foot-thick interval, locally containing, the F and G beds. The upper zone (75-to 125-foot-thick) contains beds H to L. The M bed, locally occurs along the contact with the overlying Lower Blue Gate Shale. A stratigraphic section of the Ferron Sandstone just east of the Fremont block is shown in **figure 3**. Quick and others (in press) mapped eight coalbeds in their study of the southern Emery coalfield. In ascending order these coalbeds are designated the A, CD, G, I, J, K, L, and M. **Figure 4** is an idealized stratigraphic cross section of the southern Emery coalfield that shows the relative

thickness and distribution of the eight coalbeds (Quick and others, in press). Those beds that underlie the Fremont block in measurable thicknesses (exceeding 12 inches) are the A, CD, G, I, J, K, and L.

Surface Geology of the Fremont Block

The west half of the block is primarily covered with pediment deposits of Quaternary alluvium and colluvium and exposures of the Lower Blue Gate Shale (**plate 4**). Alluvial deposits (Qal) are described as stratified clay, silt, sand, and gravel and some unsorted flood deposits. Colluvial deposits (Qg) are mainly gravel deposits consisting of partly consolidated, poorly sorted and stratified deposits of rock fragments of local origin, pediment or terrace, up to 75 feet thick. The Blue Gate is described as pale, blue-gray, nodular and irregularly bedded marine mudstone and siltstone with several arenaceous beds, [the Blue Gate] weathers into low rolling hills and badlands (Doelling, 1972).

The east half of the block mainly contains exposures of Lower Blue Gate Shale and Ferron Sandstone. Prominent sandstone lens of the Ferron Sandstone are exposed in an I-70 road cut near the center of the block. A measured section of the Ferron Sandstone just east of the block along I-70, in section 20, T. 23 S., R. 6 E. shows the Ferron to be 447.4 feet thick (Doelling, 1972).

COAL RESOURCES AND DEVELOPMENT POTENTIAL

Methods

Values for the areal extent and thickness for each coalbed were entered into a spreadsheet where the coal tonnage was calculated using a coal density value of 1,800 tons per acre-foot of coal (Wood and others, 1983).

The data set for the southern Emery coalfield consists of 530 drill holes in (and adjacent to) the study area (**plate 2**). The data set for the Walker Flat 7.5-minute quadrangle that includes the Fremont block consists of 285 drill holes. Data for each drill hole include the depth and thickness of one or more coalbeds. Drill holes that are adjacent to the study area are included to improve the reliability information shown along the edges of derived maps.

Creating Maps Using ArcView

Maps showing coalbed thickness and depth were created from drill hole data using the Spatial Analyst (v.1.1) extension for ArcView (v.3.2) software. The intersection of the coalbed elevation and surface elevation defined the coalbed outcrop, which was verified by comparison to digitized outcrop lines from Doelling (1972).

Resource Classification

The U.S. Geological Survey (USGS) (Wood and others, 1983) narrowly defines a coal reserve as coal that can be economically produced at the time of determination, whereas a coal resource is broadly defined to include coal for which economic extraction is potentially feasible. In this study, we did not rigorously consider coal-production costs, the percent of the in-ground-coal that can be recovered, or other factors required to estimate the coal reserve. Instead, we identified a subset of the in-ground coal resource, which we call the available coal resource. The available coal resource is that part of the total coal resource remaining after subtraction of coal in areas affected by past mining, or where mining is prohibited because of technical or land-use restrictions. For available surface resources, a minimum bed thickness of one foot, a minimum overburden depth of 50 feet, and a maximum waste to coal ratio of 8:1 was used as limiting parameters. For the available deep coal resource, a minimum bed thickness of four feet, a minimum overburden of 100 feet, and a maximum of 3000 feet of overburden were used as limiting parameters. To illustrate the depth of the various coal beds, overburden maps were created for the A, CD, I, and L beds on 500-foot increments.

Coal Quality

Coal quality determinations are based on 997 analytical data points within the Walker Flat 7.5-minute quadrangle and the results represent average values for coal beds contained within the quadrangle. Due to time constraints, and technical considerations, it was not feasible to constrain the model specifically to the Fremont block. However, the majority of data points within the Walker Flat 7.5-minute quadrangle are near or within the Fremont block and it is believed that the

quality data for the quadrangle is representative of the Fremont block. Since the data represents average coal values, it is not possible to map the variability of quality parameters within an individual seam across the Fremont block. However, histograms were developed for each bed to show the variability and distribution of quality parameters. Quality data are presented on a moist, whole-coal basis, due to abnormally low moisture values being reported, presumably because the samples partially dried before analysis. Moisture values reported here are calculated to approximate the expected moisture content of mined coal.

Available Coal Resources

Overview

The Fremont block contains an estimated available coal resource of 92.9 million short tons (tons) of which 89.8 million tons (97 %) are deep resources and 3.1 million tons (3 %) are surface resources (**table 3**). These coals are classified by rank as ranging from subbituminous B to subbituminous A. The beds are contained within a section that averages 308 feet in thickness.

The overwhelming majority (99 %) of the available coal resource is contained in the A, CD, I and L beds. The beds dip uniformly to the west and are under less than 1000 feet of cover. **Plates 5, 6, 7, 8, and 9** map the distribution of available surface and deep resources by thickness interval and **plates 10, 11, 12, and 13** map the depth of overburden for the available deep resources of the A, CD, I, and L beds. Available Surface and Deep coal resources for the Fremont block are shown by thickness interval for the A, CD, I, and L beds in **tables 4, 5, 6, and 7**.

Available Surface Coal Resource

Available surface coal resources are predominantly in the I bed, with minor amounts in the K and A beds. The bulk of the resource (2.8 million tons) is in section 32, T. 23 S., R. 6 E. with a minor amount in section 31, T. 23 S., R. 6 E. The distribution of available surface resources for the I bed is summarized in table 6 and mapped in plate 7. The I bed thickness ranges from 8 to 16 feet, so it is possible, using a maximum stripping ratio of 8:1, that the surface resource could extend to a depth of 128 feet. Caution should be used when considering the mineability of the available surface coal resource because additional field work is essential in establishing accurate coal outcrop locations, the extent of burned or deteriorated coal away from the outcrop, and precise topographic control for accurate geologic and mine modeling.

Available Deep Coal Resource

The available deep resources are found mainly in the A bed (54 %), CD bed (5 %), I bed (24 %), and L bed (17 %). Collectively, these seams contain 89.4 million tons or 99.6 % of the available deep resource (table 3). The distribution of these beds by thickness interval is mapped in plates 5, 6, 8, and 9. The distribution of resources for the A, CD, I, and L beds are summarized in tables 4, 5, 6, and 7. The average bed thickness and interval to the above-lying bed is shown in **table 8** and, as previously stated, represents the average interval for the Walker Flat 7.5-minute quadrangle. The average coal bed thickness was calculated based on a minimum bed thickness of 1 foot and is not representative of the available deep resource, which is based on a minimum bed thickness of four feet.

Overburden and Interburden

The depth of overburden for the A, CD, I, and L beds is mapped in plates 10, 11, 12, and 13 respectively. The mapping shows that all of the beds lie at a depth of less than 1000 feet.

Comparing the individual bed depth maps show that the beds dip uniformly to the west reflecting the general dip of the Ferron Sandstone and a relatively uniform surface topography. The A bed (plate 10) is the lowest bed in the coal section and at its deepest point is 948 feet below the surface.

For the A, CD, I, and L beds, the interval between successive beds is 45.5 feet, 114.1 feet, and 84.6 feet respectively. Interburden layers were not modeled in ArcView mainly because of the accuracy of drill hole elevations, bed correlations, and the proximity of data points over portions of the coalfield. In certain areas of the Walker Flat 7.5-minute quadrangle, including the Fremont block, it is probable that the A bed and the I bed are closer together than 40 feet. Where this has occurred only one of the beds has been included in the available resource calculation.

Coal Quality and Rank

Coal quality data for seven beds in the Walker Flat 7.5-minute quadrangle are summarized in **table 9 and figure 5**. There is no quality data for the M bed within the Walker Flat 7.5-minute quadrangle.

Discussion of Data

Figure 5 shows that the ash, sulfur, and BTU values vary within and among the coalbeds. The upper coalbeds (J, K, and L,) contain more sulfur than the lower coalbeds (A, CD, G, and I). The relatively high ash values observed for the CD bed might be partly due to volcanic ash parting material included in analysis specimens (**Crowley and others, 1989**). The coal rank varies among the coal beds from high volatile B bituminous to subbituminous A. Other observations are:

1. Moisture values were calculated to compensate for inconsistent “as received” analytical data.
2. The number of sample points for the L bed are minimal, and most likely representative of only a small part of the resource for that bed.
3. Average ash values range from a low of 9.1 % (I bed) to a high of 15.2 % (J bed)
4. Average sulfur values exceed 2 % on the J, K, and L beds making them less desirable.
5. BTU values on a moist whole-coal basis range from a low of 10,462 (CD bed) to a high of 11,542 (I bed) and are indicative of the change in ash content from one seam to another (i.e. the I bed, which has the highest BTU value also has the lowest ash value).
6. The histograms (figure 5) show that the quality values for each seam show a wide range in variability. This is likely as indicative of the inconsistency in sample handling and storage as it is of the resultant analytical value.

Coal Development Potential

The coal development potential for the Fremont block is favorable. The available surface coal resource is less certain than the available deep coal resource due to the accuracy of coal outcrop elevations and shallow depths near the outcrop. Available deep coal resources are more accurately

defined, however, access to available deep resources varies from bed to bed according to its proximity to outcrop.

Available Surface Resources

Available surface coal resources are estimated to be 3.1 million tons in the Fremont block (table 3). Available surface resources are located primarily in the I bed (2.8 million tons) with a minor amount in the A bed. The available surface resource for the I bed is mainly located in the S½ section 32, T. 23 S., R. 6 E (plate 7). Potential access is available west of the outcrop in this area. Because of the variability in outcrop elevations, the gentle relief in the Dog Valley Wash area, and the extent of burned or weathered coal, a great deal of caution must be used when considering the mineability of any surface resources.

Available Deep Resources

Available deep coal resources in the A bed are estimated to be 48.6 million tons in the Fremont block (table 3). Outcrop access is located in the SE¼ section 32, T. 23 S., R. 6 E. (plate 5). The A bed is partially or entirely washed out in the Dog Valley Wash area, but entries could be extended through the wash out at the narrowest distance, which appears to be in section 30, T. 23 S., R. 6 E.

Available deep coal resources in the CD bed are estimated to be 4.3 million tons in the Fremont block (table 3). There appears to be no direct outcrop access to the available deep coal and access to the majority of the resource in section 19, T. 23 S., R. 6 E. would require a sloped entry. Access

to the CD bed could also be gained from the A bed by ramping upward (approximately 45 feet vertically) or from the I bed by ramping downward (approximately 114 feet vertically). The average BTU value for the CD bed is 10,426, which may limit or prohibit the marketability of the coal resource. The relatively small resource in the CD bed may also limit its development potential.

Available deep coal resources in the I bed are estimated to be 21.2 million tons in the Fremont block (table 3). Available deep resources are located primarily in the west half of the block and would require an extended entry development of approximately 1 mile from outcrop (plate 8). Decline entries could also be located in sections 24, 25, and 36, T. 23 S, R. 5 E., and in section 2, T. 24 S., R. 5 E.

Available deep coal resources for the L bed are estimated to be 15.3 million tons in the Fremont block (table 3). The available resource for the L bed is located in the central part of the block and would require extended entry development of approximately one-half mile from outcrop (plate 9). The apparent closest outcrop is in section 31, T. 23 S., R. 6 E. Because of the relatively high sulfur content of the L bed (average 3.4 %), the marketability of coal from this bed is highly unlikely.

DEVELOPMENT POTENTIAL FOR OIL AND GAS, CARBON DIOXIDE, HELIUM, AND INDUSTRIAL MINERALS IN THE SOUTHERN EMERY COALFIELD AREA

Gloyn and others (2003) in their evaluation of the energy, mineral, and ground-water resources of Carbon and Emery Counties outlined the potential for development of several resources in the southern Emery coalfield area. In addition to coal, these minerals include oil and gas, carbon dioxide, and helium; sand and gravel and crushed stone; clay and bentonite; building and dimension stone; and humate. There are numerous other commodities that have development potential in Emery County, but are in areas outside the Fremont block area and in strata that lie both above and below the coal-bearing Ferron Sandstone.

Oil and Gas, Carbon Dioxide, and Helium

History and Past Production

Emery County has significant gas production and some oil production. Hydrocarbons were first discovered in Emery County with the completion of a gas well in Last Chance field in 1935 (plate 1). The only production reported was gauged during testing of the Triassic Moenkopi Formation. There is no pipeline in the area, and the field has never been commercially produced. The first commercial production of hydrocarbons was from the Ferron Sandstone reservoir at Clear Creek field, which is in both Carbon and Emery Counties. The first oil was discovered at the Ferron field in 1957, but the first production was from Grassy Trail field, which also extends into Carbon County. More oil has been produced from Grassy Trial field than any other field in Carbon or Emery County (Gloyn and others, 2003).

As of December 31, 2003, Emery County had 265 active oil and gas wells. Cumulative production to the end of 2003 was 110,344,135 million cubic feet of gas (MCFG), 680,387 barrels of oil (BO), and 36,256,606 barrels of water (BW) as reported by the DOGM in their monthly county production reports, updated as of April 13, 2004 (**Utah Division of Oil, Gas, and Mining, 2004a**). This report and other statistical oil and gas data is located on DOGM's web site at the following URL: http://ogm.utah.gov/oilgas/PUBLICATIONS/Reports/PROD_book_list.htm

Current Production and Trends

DOGM reports that 2003 Emery County production, as of April 13, 2004, was 17,211,996 MCFG including coalbed methane, 6351 BO, and 7,269,176 BW. At the end of 2003, oil was being produced in the Grassy Trail and Ferron fields, and natural gas and coal bed methane were being produced in the Buzzard Bench, Drunkards Wash, Ferron, Flat Canyon, Grassy Trial fields, and from unassigned wells. Most conventional gas production is from the Ferron and Flat Canyon gas fields, which together have produced more than 21,500 MCFG from the Ferron Sandstone. Coal bed methane is mostly from the Drunkards Wash field, which extends into Emery County, and from the Buzzard Bench field. DOGM reports that as of April 13, 2004, coal bed methane production in Emery County for 2003 was 16,649,674 MCFG (**Utah Division of Oil, Gas, and Mining, 2004b**). Coal bed methane production data is available on DOGM's web site at http://ogm.utah.gov/oilgas/STATISTICS/production/coalbed/ACB_GASPROD.HTM

The majority of the gas currently produced in Carbon and Emery Counties is from sandstone and coal beds in the Ferron Sandstone. Oil production in Emery County is from the Moenkopi

Formation. Gas production had been declining in both counties, but dramatically increased beginning in 1993 with the exploitation of coal bed methane from the Ferron Sandstone. Oil production continues to decline in Carbon and Emery Counties. Since 1980, all new field discoveries in the two counties have been gas producers (Gloyn and others, 2003).

Since 1989, only a few miles of seismic lines have been permitted in Carbon and Emery Counties, indicating that structural traps have not been a significant exploration target in this area. Drilling for oil and gas (other than coal bed methane) will likely continue to be minimal unless a new play is discovered (Gloyn and others, 2003).

Potential for Additional Discoveries and/or Development

Carbon and Emery Counties have produced oil and gas from both shallow and deep reservoirs, ranging in age from Tertiary to Permian. There are several plays that are productive or have the potential to be productive (**table 10**). These play areas cover all of the southern Emery coalfield including the Fremont block.

Ferron play:

Sandstone and coal beds in the Ferron Sandstone contain the largest number of fields and produce the majority of the gas in the Carbon-Emery County area. Individual beds in the Ferron are typically 10 to 20 feet thick and are at depths of 1500 to 6500 feet. Early discoveries were structural traps with gas contained in the sandstone beds. More recent discoveries are stratigraphic traps with gas entrapped in the coal beds. The majority of new field discoveries in Carbon and

Emery Counties will probably continue to be in Ferron reservoirs. Exploration companies initially explored by mapping surface structures. Today, the most common exploration method is subsurface mapping of coal-bed and sandstone thickness and structure. The Ferron play area covers more than 1800 square miles in western Emery County, and western and northeastern Carbon County. In western Emery County, the play is limited on the east by the outcrop of the Ferron. In eastern Carbon County the play is limited on the south by the depositional pinchout of porous sandstone and coal beds.

Moenkopi play:

Oil is produced from the Moenkopi Formation at Grassy Trail field, the largest oil field in Emery County. The Moenkopi reservoirs consist of shallow-marine sandstone deposits, probably tidal channels and estuary fill, (**Lutz and Allison, 1991**). The sandstone beds are typically less than 10 feet to 20 feet thick and occur at a depth of approximately 3900 feet. Grassy Trail is the only field currently producing from the Moenkopi, but drilling oil shows, seeps, and tar sands have been reported throughout the region, and 132 BO was produced from the Buzzard Bench field during 1982. The most common exploration method for Moenkopi reservoirs in this area is subsurface thickness and structure mapping of depositional facies and individual beds to identify potential hydrocarbon traps. The play area covers all of Emery County except the portion of the San Rafael Swell where Moenkopi and older rocks are exposed.

Kaibab play:

More than 38,000 BO was produced from the Permian Kaibab Formation (Black Box Dolomite) at Ferron field. The Kaibab reservoir consists of dolomitic limestone deposited in a shallow-water

shelf environment (**Kiser, 1976**). Production from the Kaibab is believed to be structural, but oil shows and subsurface mapping indicate a potential for stratigraphic and hydrodynamic traps as well (**Goolsby and others, 1988; Tripp, 1993**). The most common exploration method for Kaibab reservoirs in this area is subsurface thickness and structure mapping of depositional facies and porosity trends, and determining ground-water flow patterns to identify potential hydrocarbon traps. The play covers all of Emery County excluding the portion of the San Rafael uplift defined by the outcrop of Moenkopi and older rocks.

Leadville play:

The Mississippian Leadville (Redwall) Limestone is productive in Grand and San Juan Counties (**Morgan, 1993, 1994**), but is not productive in Carbon or Emery County. The Leadville reservoir varies from limestone to dolomitic limestone to dolomite. It ranges in thickness from less than 10 feet to more than 1000 feet. Production from the Leadville is structurally controlled.

Unfortunately, the known structures in Carbon and Emery Counties have been tested and the Leadville was found to be nonproductive. A better understanding of source and migration of hydrocarbons may lead to less obvious but productive structures. The most common exploration method for Mississippian reservoirs in this area is subsurface structure mapping to identify potential hydrocarbon traps. The play covers all of Emery County.

Carbon Dioxide and Helium

Carbon dioxide-rich gas has been tested from the Jurassic Navajo, Triassic Moenkopi, and Permian Kaibab (Black Box Dolomite) and White Rim Formations. Also, some Mississippian-

aged carbonate reservoirs in Carbon and Emery Counties may contain large quantities of CO₂-rich gas. Most of the CO₂-rich gas in Emery County contains a high percentage of N₂ which greatly reduces the value of the CO₂. Farnham Dome and Gordon Creek fields in Carbon County contain 99 percent pure CO₂. The reservoirs in Emery County have little or no potential for exploitation.

Helium-rich gas has been tested from the Triassic Moenkopi, Permian Kaibab (Black Box) and White Rim, and Devonian Elbert Formations. Helium-rich gas in Carbon and Emery Counties is associated with CO₂ and N₂, greatly increasing the cost to extract the He. Helium is usually extracted from hydrocarbon gases as a by-product. Currently, there are no known He-rich reservoirs in Emery County that have sufficient hydrocarbons to make He an economical resource.

Industrial Minerals

Sand and gravel and crushed stone:

Locally, sand and gravel were mined as needed from alluvial deposits for local construction and road building. The use of crushed stone is known, but not well documented and there are no known locations in Emery County. Sand and gravel occurrences are abundant in the area and several sites were developed for the construction of I-70 (plate 4). The only active site is located in the SE1/4 of section 35, T. 23 S., R. 5 E. on U.S. Bureau of Land Management (BLM) lands. UDOT has a material permit to extract sand and gravel on part of the Fremont block. Geologic mapping for the Walker Flat 7.5-minute quadrangle (Doelling 1972) shows large areas of Quaternary alluvium (Qa) and gravel (Qg) occurrences, and a substantial part of the Fremont block is overlain with these deposits that potentially could yield suitable sand and gravel.

Clay and bentonite:

Common clay is mined from alluvial deposits and used for lining ditches, waste disposal sites, and for other civil engineering and construction purposes. Western Clay Company sporadically produces a sodium bentonite clay from the Last Chance mine (plate 2). The clay is in the Mussentuchit Member of the Cedar Mountain Formation. In northern Emery County near the town of East Carbon, ECDC Environmental LC periodically produces clay from the Tununk Shale. The material is used for lining waste disposal cells at the company's East Carbon landfill site. The potential for locating new clay and bentonite resources is good although the quality of such deposits are unknown and their location in the San Rafael Swell area may inhibit exploration and mining. There appears to be little development potential for clay or bentonite within the southern Emery coalfield and particularly within the Fremont block.

Building and dimension stone:

While there are plentiful resources of sandstone for use in building and ornamental applications, there has been no commercial stone development in Emery or Carbon Counties. A stone cutting and finishing facility is located near the town of Wellington that processes stone from Wayne County. The finished stone is used mainly for commercial purposes outside of Utah (Weston Hanson, Wes Hanson's Quality Stone, personal communication, April 2004). There are numerous sandstone occurrences within the southern Emery coalfield, but apparently these are not of sufficient quality or attractiveness to warrant development. Within the Fremont block, there are several sites along I-70 that contain large blocks of Ferron Sandstone. These sites are well exposed and are reasonably accessible. There has been no interest shown in developing this area and the proximity to I-70 may actually be a hindrance to development due to scenic concerns.

R.W. Gloyn (personal communication) notes that the Ferron Sandstone in this area is too distant and of questionable quality to be considered a potential source for either crushed or building stone.

Humate:

Humate is produced locally by a few operators and production dates back to the late 1980s. Two humate processing facilities are located in the town of Emery. Humate is used as both a nutritional trace element supplement for humans and as a soil amendment and fertilizer. Humate is a weathered coal or carbonaceous mudstone or shale that contains large amounts of humic acids. Humic acids are mixtures of colloidal organic molecules, with molecular weights between 5,000 and 50,000, that result from decay of organic matter (**Siemers and Waddell, 1997**). The quality of the humate or weathered coal increases with increasing humic acid content. The humic acid content of weathered coal typically increases with the degree of weathering (**Hoffman and others, 1994**).

Despite the large areas with potential humate and weathered organic shale in Carbon and Emery Counties, scant information exists on the nature and extent of these resources. All of the permitted humate or humic shale mines in the state are located within the southern Emery coalfield north of the Fremont block (plate 2) and several of these mines are located on state-owned lands. These mines are located in areas adjacent to or near the shallow coal outcrops in the Ferron Sandstone. Similar areas within the Fremont block are potential areas for future development. These areas are found in sections 30, 31, and 32, T. 23 S., R. 6 E.

RECOMMENDATIONS FOR FURTHER EVALUATION

A GIS-based analysis of data used to estimate the coal resource potential for the southern Emery coalfield was applied to the much smaller Fremont block. The map representations, resource calculations, and qualitative summaries are statistically based and, to a certain degree, lack refinement. For example, the quality analysis is inclusive of the Walker Flat 7.5-minute quadrangle and was not constrained to the Fremont block. Other areas lacking refinement include seam correlation and mineable thickness determination, which was not possible for the entire southern Emery coalfield. With this in mind, I recommend that a refinement of the data be made to include the following:

1. Confine the data set to the Fremont block and lands within one mile of the block.
2. Refine drill-hole data by going back to the original drill hole data or geophysical logs to establish a mineable bed thickness, taking into consideration riders, partings, and splits. Re-correlate the A, CD, I, and L beds as necessary.
3. Refine the quality data to a consistent level of reliability and re-evaluate the quality of the A, CD, I, and L beds and compare that to the estimate in this evaluation.
4. Re-evaluate the available deep resource for the A and I beds and compare that to the resource estimate in this evaluation.

5. Prepare a depositional model for the A and I beds within the Fremont block if sufficient data is available.
6. Examine the outcrop of the A and I beds for suitable entry locations.

To look at the deeper oil and gas potential, I recommend that an attempt be made to map the underlying strata to identify any structures in the Moenkopi, Kaibab, and Leadville Formations.

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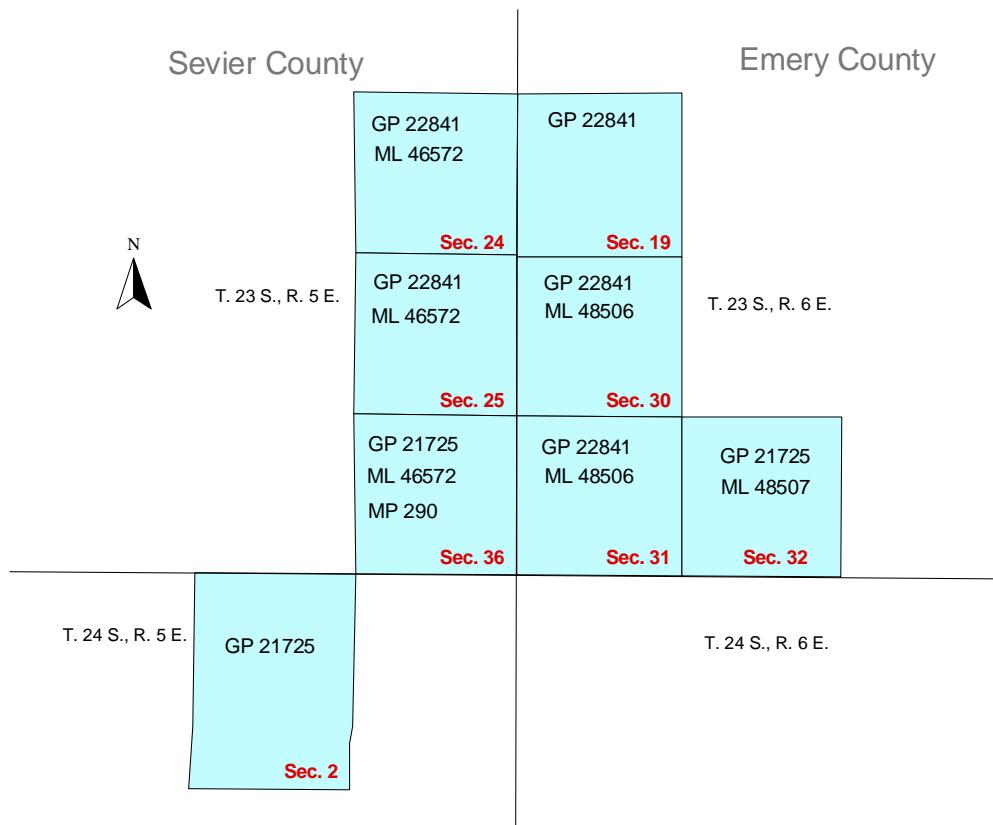


Figure 1. Diagram showing the location of grazing permits (GP), material permits (MP), and mineral leases (ML) on the Fremont block. (Data from State and Institutional Trust Lands Administration)

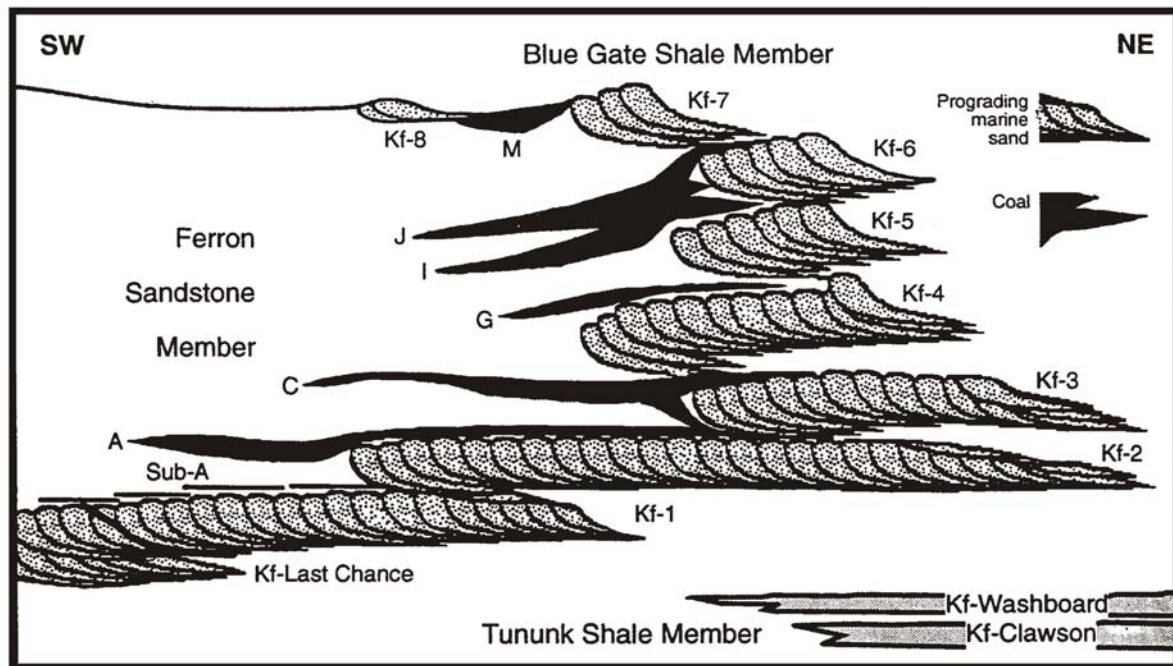


Figure 2. Diagrammatic cross section of the Ferron Sandstone and adjacent members of the Mancos Shale showing the numbering and stacking of the delta-front units. Coal zones are designated by letters. (From Chidsey, 2002)

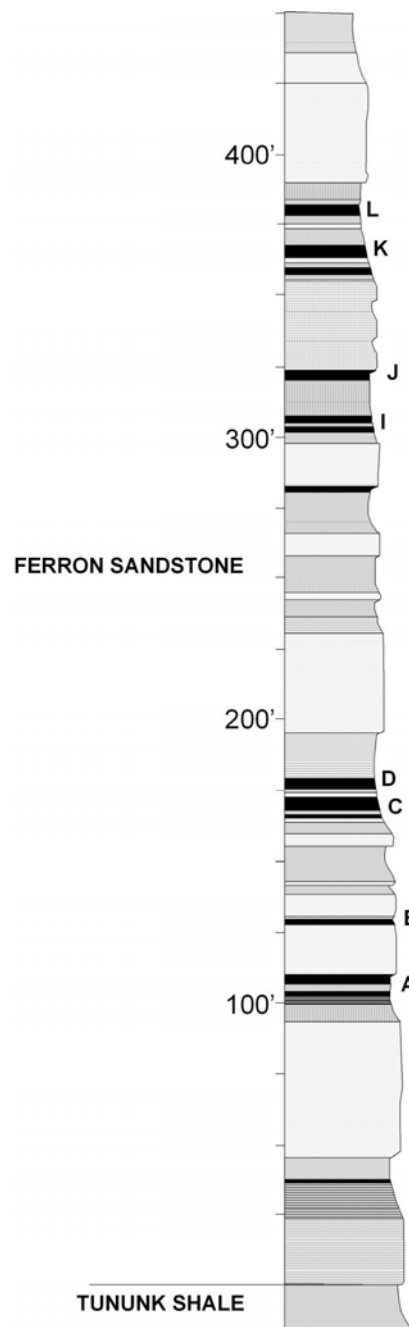


Figure 3. Composite stratigraphic section of coal beds in the Ferron Sandstone near the Fremont block (sections 20 and 21, T. 23 S., R. 6 E, SLBM). (modified from Doelling, 1972)

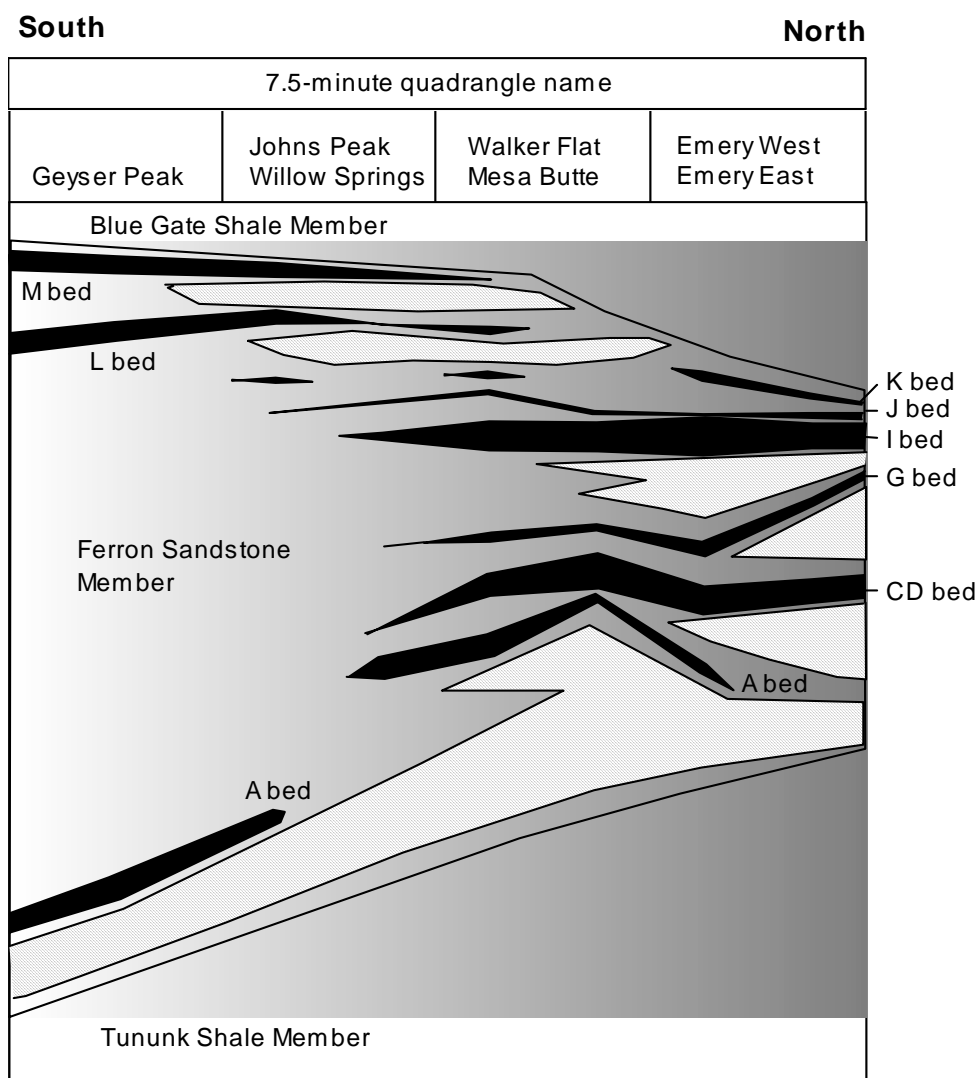


Figure 4. Idealized stratigraphic cross section showing eight coalbeds in the Ferron Sandstone Member of the Mancos Shale, southern Emery coalfield, Emery and Sevier Counties, Utah. The thickness and distribution of the coalbeds are based on drill hole data from the 7.5-minute quadrangle listed at the top of the figure. The thickness and distribution of associated sandstones (striped pattern) are qualitative and modified from Ryer (1981). (from Quick and others, in press)

Table 1. Active and inactive mines in the southern Emery coalfield, Emery and Sevier Counties, Utah. (modified from Quick and others, in press)

DOGM Mine ID	Mine Status	Mine Name	Commodity	Operator	Location		
					T	R	S
S150053	INA	Clark #1 / Emeryide	Humic Shale	Clark, Robert L.	22S	6E	26
S150046	INA	Daddy Dearest	Humic Shale	Thomas J. Clark	22S	6E	26
S150043	ACT	Miller Rock/Bret Clark	Humic Shale	Hub Research & Dev.	22S	6E	26
C150015	INA	Emery Mine	Coal	Consolidation Coal Company	22S	6E	30
M150040	ACT	Rockland Mine (Body Tody)	Humic Shale	Miracle Rock Mining & Research	23S	6E	2
S150074	INA	Number 1 Clark	Humic Shale	Clark, Robert L.	23S	6E	2
S150076	INA	TJ Clark Mine	Humic Shale	Freemont Corporation	23S	6E	2
S150090	ACT	The Rockland Mine	Humic Shale	The Rockland Corp.	23S	6E	2
S150052	ACT	Co-Op Placer Project	Humic Shale	Co-Op Mining Co.	23S	6E	3
S150081	ACT	Walker Flat	Humic Shale	Miracle Rock Mining	23S	6E	7
M150061	ACT	Last Chance #25 & #26	Bentonite	Western Clay Company	25S	6E	8

Note: ACT = active, INA = inactive

Table 2. Fremont block summary of surface and material permits, and mineral leases.

Location	Permit	Type	Held by	Issue	Expiration
T. 23 S., R. 5 E.					
Section 24	GP 22841	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2016
	ML 46572	OGH	Chevron USA, Inc	6/1/1994	5/31/2004
Section 25	GP 22841	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2016
	ML 46572	OGH	Chevron USA, Inc	6/1/1994	5/31/2004
Section 36	GP 21725	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2006
	ML 46572	OGH	Chevron USA, Inc	6/1/1994	5/31/2004
	MP 290	SDG	UDOT	10/1/2003	9/30/2008
T. 23 S., R. 6 E.					
Section 19	GP 22841	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2016
Section 30	GP 22841	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2016
	ML 48506	Clay	Wayne Hunt	8/1/1998	7/31/2008
Section 31	GP 22841	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2016
	ML 48506	Clay	Wayne Hunt	8/1/1998	7/31/2008
Section 32	GP 21725	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2006
	ML 48507	Clay	Wayne Hunt	8/1/1998	7/31/2008
T. 24 S., R. 5 E.					
Section 2	GP 21725	Grazing	Johnson Livestock Oak Ranch	7/1/2001	6/30/2006

Note: OGH=oil, gas, and hydrocarbons, SDG=sand and gravel, GP=grazing permit,

MP=material permit, ML=mineral lease.

Table 3. Available coal resources for the Fremont block, Emery and Sevier Counties, Utah. Data shown in millions of tons.

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
COALBED									
M surface	0	0	0	0	0	0	0	0	0
M deep	0	0	0	0	0	0	0	0	0
L surface	0	0	0	0	0	0	0	0	0
L deep	3.0	2.2	2.4	3.6	3.0	1.1	0	0	15.3
K surface	0	0	0	0	0	0	0.2	0	0.2
K deep	0	0	0	0	0	0	0	0	0
J surface	0	0	0	0	0	0	0	0	0
J deep	0	0	0	0	0	0	0	0	0
I surface	0	0	0	0	0	0.3	2.5	0	2.8
I deep	4.6	6.9	3.3	0.1	0	0	0.6	5.7	21.2
G surface	0	0	0	0	0	0	0	0	0
G deep	0	0	0	0	0	0	0.4	0	0.4
CD surface	0	0	0	0	0	0	0	0	0
CD deep	1.3	0.5	0	2.1	0	0	0.4	0	4.3
A surface	0	0	0	0	0	0	0.1	0	0.1
A deep	8.5	5.2	5.3	8.2	4.9	6.2	7.6	2.7	48.6
Total surface	0	0	0	0	0	0.3	2.8	0	3.1
Total deep	17.4	14.8	11.0	14.0	7.9	7.3	9	8.4	89.8
GRAND TOTAL	17.4	14.8	11.0	14.0	7.9	7.6	11.8	8.4	92.9

Notes:

Deep coal is coal that can be mined by underground mining methods, in beds more than 4 feet thick, between 100 and 3,000 feet deep, excluding coal made unavailable due to land-use restrictions (under perennial streams, roads, buildings, or power lines).

Surface coal is coal that can be mined by surface mining methods where the net overburden to coal ratio is less than eight, excluding coal less than 50 feet deep (presumably oxidized or burned), coal in beds less than one foot thick, and coal made unavailable due to land-use restrictions (under perennial streams, roads, buildings, or power lines).

Table 4. Available surface and deep coal resources in the A coalbed, by bed thickness, for the Fremont block, Emery and Sevier Counties, Utah. Data shown in millions of tons.

Surface Resources

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft	0	0	0	0	0	0	0	0	0
2 to 4 ft	0	0	0	0	0	0	0	0	0
4 to 6 ft	0	0	0	0	0	0	0	0	0
6 to 8 ft	0	0	0	0	0	0	0	0	0
8 to 10 ft	0	0	0	0	0	0	0.1	0	0.1
10 to 12 ft	0	0	0	0	0	0	0	0	0
12 to 14 ft	0	0	0	0	0	0	0	0	0
14 to 16 ft	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0.1	0	0.1

Deep Resources

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
2 to 4 ft *	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.6	*
4 to 6 ft	0.0	0.4	0.6	0.3	1.6	0.7	0.0	2.7	6.3
6 to 8 ft	1.7	4.8	4.2	1.1	2.8	2.8	0.9	0.0	18.3
8 to 10 ft	3.6	0.0	0.5	1.3	0.5	2.1	3.2	0.0	11.2
10 to 12 ft	1.2	0.0	0.0	4.4	0.0	0.6	2.8	0.0	9
12 to 14 ft	2.0	0.0	0.0	1.1	0.0	0.0	0.7	0.0	3.8
14 to 16 ft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	8.5	5.2	5.3	8.2	4.9	6.2	7.6	2.7	48.6

Note: *Coalbeds for surface resources less than one foot thick are excluded from totals.

* Coalbeds for deep resources less than 4 feet thick are excluded from totals.

Table 5. Available surface and deep coal resources in the CD coalbed, by bed thickness, for the Fremont block, Emery and Sevier Counties, Utah. Data shown in millions of tons.

Surface

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft									
2 to 4 ft									
4 to 6 ft	No significant surface coal resources								0
6 to 8 ft									0
8 to 10 ft									0
10 to 12 ft									0
12 to 14 ft									0
14 to 16 ft									0
Total	0	0	0	0	0	0	0	0	0

Deep

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft *	0	0	0	0	0	0	0	0	0
2 to 4 ft *	0	0	0	0	0	0	0	0	0
4 to 6 ft	1.3	0.5	0	2.1	0	0	0.4	0	4.3
6 to 8 ft	0	0	0	0	0	0	0	0	0
8 to 10 ft	0	0	0	0	0	0	0	0	0
10 to 12 ft	0	0	0	0	0	0	0	0	0
12 to 14 ft	0	0	0	0	0	0	0	0	0
14 to 16 ft	0	0	0	0	0	0	0	0	0
Total	1.3	0.5	0	2.1	0	0	0.4	0	4.3

Note: *Coalbeds for surface resources less than one foot thick are excluded from totals.

*Coalbeds for deep resources less than 4 feet thick are excluded from totals.

Table 6. Available surface and deep coal resources in the I coalbed, by bed thickness, for the Fremont block, Emery and Sevier Counties, Utah. Data shown in millions of tons.

Surface

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft	0	0	0	0	0	0	0	0	0
2 to 4 ft	0	0	0	0	0	0	0	0	0
4 to 6 ft	0	0	0	0	0	0	0	0	0
6 to 8 ft	0	0	0	0	0	0	0	0	0
8 to 10 ft	0	0	0	0	0	0.1	0	0	0.1
10 to 12 ft	0	0	0	0	0	0.2	0.5	0	0.7
12 to 14 ft	0	0	0	0	0	0	1.9	0	1.9
14 to 16 ft	0	0	0	0	0	0	0.1	0	0.1
Total	0	0	0	0	0	0.3	2.5	0	2.8

Deep

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft *	0	0	0	0.4	0.8	0.1	0	0.1	*
2 to 4 ft *	1.1	0.3	1.7	2.6	1.6	1.8	0	1.2	*
4 to 6 ft	2.8	1.0	2.1	0.1	0	0	0	3.9	9.9
6 to 8 ft	1.3	3.2	0.8	0	0	0	0.1	0.6	6
8 to 10 ft	0.5	2.5	0.4	0	0	0	0.1	1.2	4.7
10 to 12 ft	0	0.2	0	0	0	0	0.3	0	0.5
12 to 14 ft	0	0	0	0	0	0	0.1	0	0.1
14 to 16 ft	0	0	0	0	0	0	0	0	0
Total	4.6	6.9	3.3	0.1	0	0	0.6	5.7	21.2

Note: *Coalbeds for surface resources less than one foot thick are excluded from totals.

*Coalbeds for deep resources less than four feet thick are excluded from totals.

Table 7. Available surface and deep coal resources in the L coalbed, by bed thickness, for the Fremont block, Emery and Sevier Counties, Utah. Data shown in millions of tons.

Surface

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft									0
2 to 4 ft									0
4 to 6 ft	No significant surface resources								
6 to 8 ft									0
8 to 10 ft									0
10 to 12 ft									0
12 to 14 ft									0
14 to 16 ft									0
Total	0	0	0	0	0	0	0	0	0

Deep

Township, Range section	23 S., 5 E.			23 S., 6 E.				24 S., 5 E.	Total
	24	25	36	19	30	31	32	2	
Coalbed Thickness									
1 to 2 ft *	0.2	0.1	0.2	0	0.1	0	0	0	*
2 to 4 ft *	1.4	1.4	0.9	0.4	0.7	0.1	0	0	*
4 to 6 ft	2.1	1.0	1.2	1.0	1.0	0.5	0	0	6.8
6 to 8 ft	0.9	1.2	1.2	1.0	2.0	0.6	0	0	6.9
8 to 10 ft	0	0	0	0.7	0	0	0	0	0.7
10 to 12 ft	0	0	0	0.9	0	0	0	0	0.9
12 to 14 ft	0	0	0	0	0	0	0	0	0
14 to 16 ft	0	0	0	0	0	0	0	0	0
Total	3.0	2.2	2.4	3.6	3.0	1.1	0	0	15.3

Note: *Coalbeds for surface resources less than one foot thick are excluded from totals.

*Coalbeds for deep resources less than four feet thick are excluded from totals.

Table 8. Average coal bed and interburden thickness for the Fremont block, Emery and Sevier Counties, Utah. Data from 285 drill holes from the Walker Flat 7.5-minute quadrangle show an average coal section thickness of 308 feet, with an average 33 feet net coal.

Coal bed/interval	Feet	Number of observations
M coal bed thickness	0.5	119
L bed to M bed interburden thickness	37.5	4
L coal bed thickness	1.6	177
K bed to L bed interburden thickness	32.9	44
K coal bed thickness	1.9	220
J bed to K bed interburden thickness	20.3	70
J coal bed thickness	2.1	244
I bed to J bed interburden thickness	27.4	116
I coal bed thickness	9.9	264
G bed to I bed interburden thickness	76.0	139
G coal bed thickness	2.5	216
CD bed to G bed interburden thickness	35.6	143
CD coal bed thickness	6.8	216
A bed to CD bed interburden thickness	45.5	157
A coal bed thickness	7.9	196

Table 9. Average coal quality values for the Walker Flat 7.5-minute quadrangle, Emery and Sevier Counties, Utah.

		<u>COAL BED</u>						
		A	CD	G	I	J	K	L
<u>Ash</u>								
(moist, whole-coal basis)								
average		10.3	15.1	10.4	9.1	15.2	11.9	11.8
median		8.7	15.5	7.9	7.5	15.9	9.6	11.8
standard deviation		5.8	4.9	4.6	5.0	6.3	6.5	1.4
<u>Sulfur</u>								
(% , moist, whole-coal basis)								
average		1.1	0.8	1.4	0.7	2.0	2.1	3.4
median		0.7	0.6	1.2	0.5	1.9	2.0	3.5
standard deviation		1.0	0.4	0.6	0.6	1.2	1.1	0.3
<u>Moisture</u> ¹								
(% , whole-coal basis)								
average		10.5	11.1	9.5	10.0	11.4	10.7	8.9
median		9.9	11.2	9.4	9.6	11.2	10.0	8.9
standard deviation		2.5	1.8	1.4	2.1	1.9	2.1	0.8
<u>Btu/lb</u>								
(moist, whole-coal basis)								
average		11,260	10,426	11,453	11,542	10,369	10,993	11,393
median		11,600	10,361	11,904	11,837	10,338	11,500	11,572
standard deviation		1,245	951	950	1,034	1,242	1,335	324
<u>Btu/lb</u> ²								
(moist, mineral-matter free)								
average		12,652	12,463	12,922	12,803	12,414	12,613	13,146
median		12,823	12,442	12,962	12,912	12,480	12,845	13,140
standard deviation		667	499	382	556	560	616	208
Number of Analysis Samples		178	52	17	635	43	40	3

¹ Reported moisture values are anomalously low (generally 2 to 5 %), presumably because the samples partially dried before analysis. Moisture values listed here are calculated to approximate the expected moisture content of mined coal. Moisture was estimated from the equation: Moisture = $522.6 - 0.06318 \times \text{Btu/lb}_{daf} + 1.909^{-6} \times \text{Btu/lb}_{daf}^2$, where the Btu/lb value is expressed on a dry, ash-free basis.

² Calculated using the equation listed in: American Society for Testing and Materials, 1990, D 388-90, Standard classification of coals by rank: West Conshohocken, Pennsylvania, v. 05.05, p. 193-196.

Table 10. Primary oil and gas plays in Emery County, Utah. Plays are listed from most likely to least likely to result in new field discoveries. (modified from Gloyn and others, 2003)

Play Name	Reservoir(s)	Trap Type	Location
Ferron	Ferron Sandstone sandstone and coal beds	Structural and stratigraphic	West Emery and Carbon, and northeast Carbon
Moenkopi	Moenkopi Formation	Stratigraphic	Area-wide excluding San Rafael uplift ¹
Kaibab	Kaibab Formation (Black Box Dolomite)	Structural and possibly Stratigraphic	Area-wide excluding San Rafael uplift ¹
Leadville	Leadville (Redwall) Limestone	Structural	Area-wide

¹San Rafael uplift for this table is defined as the area of the uplift where the Moenkopi or older formations are exposed.

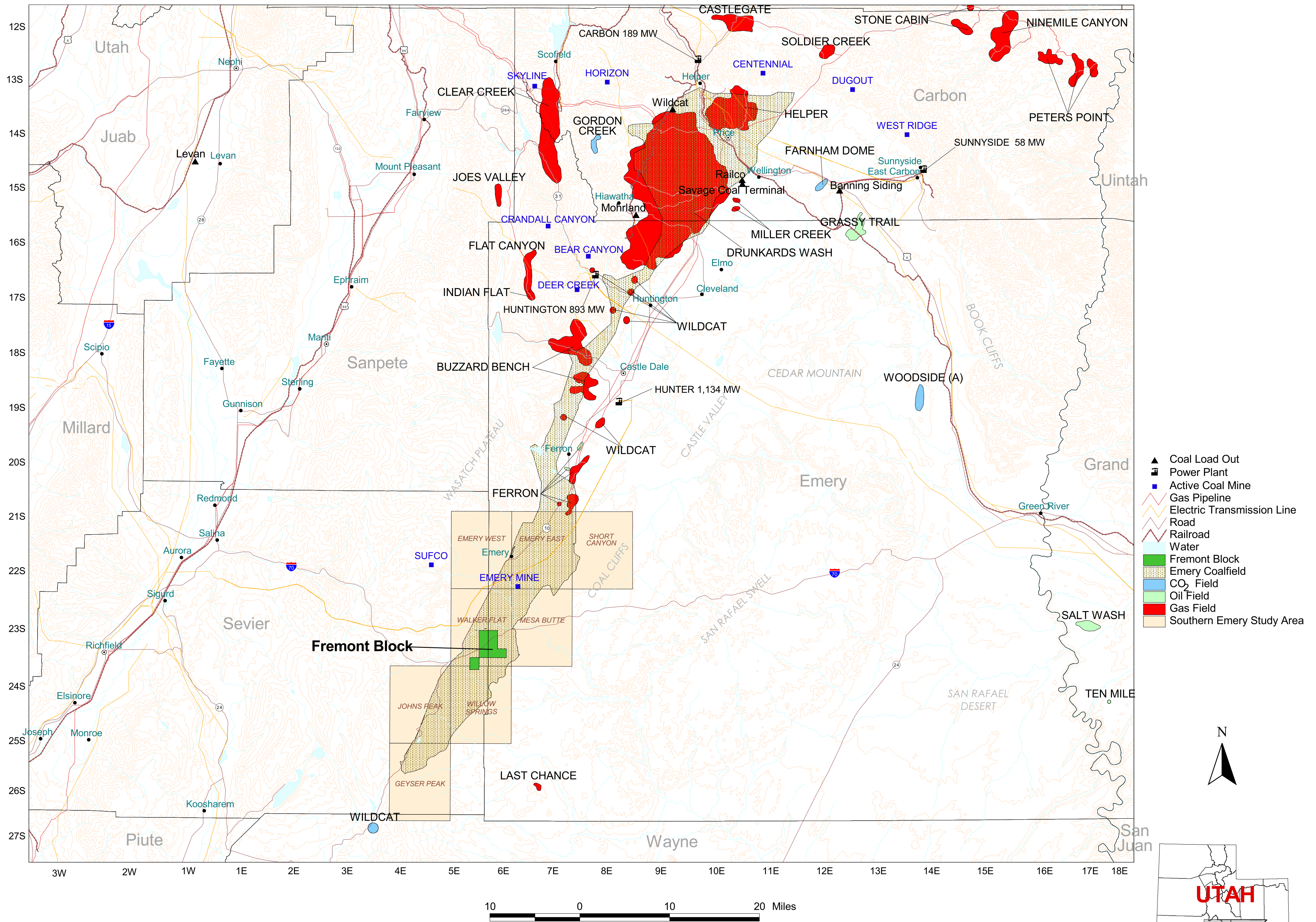


Plate 1. Regional location of the Fremont block, Emery and Sevier Counties, Utah. 7.5-minute quadrangle names for the southern Emery study area are shown in brown.

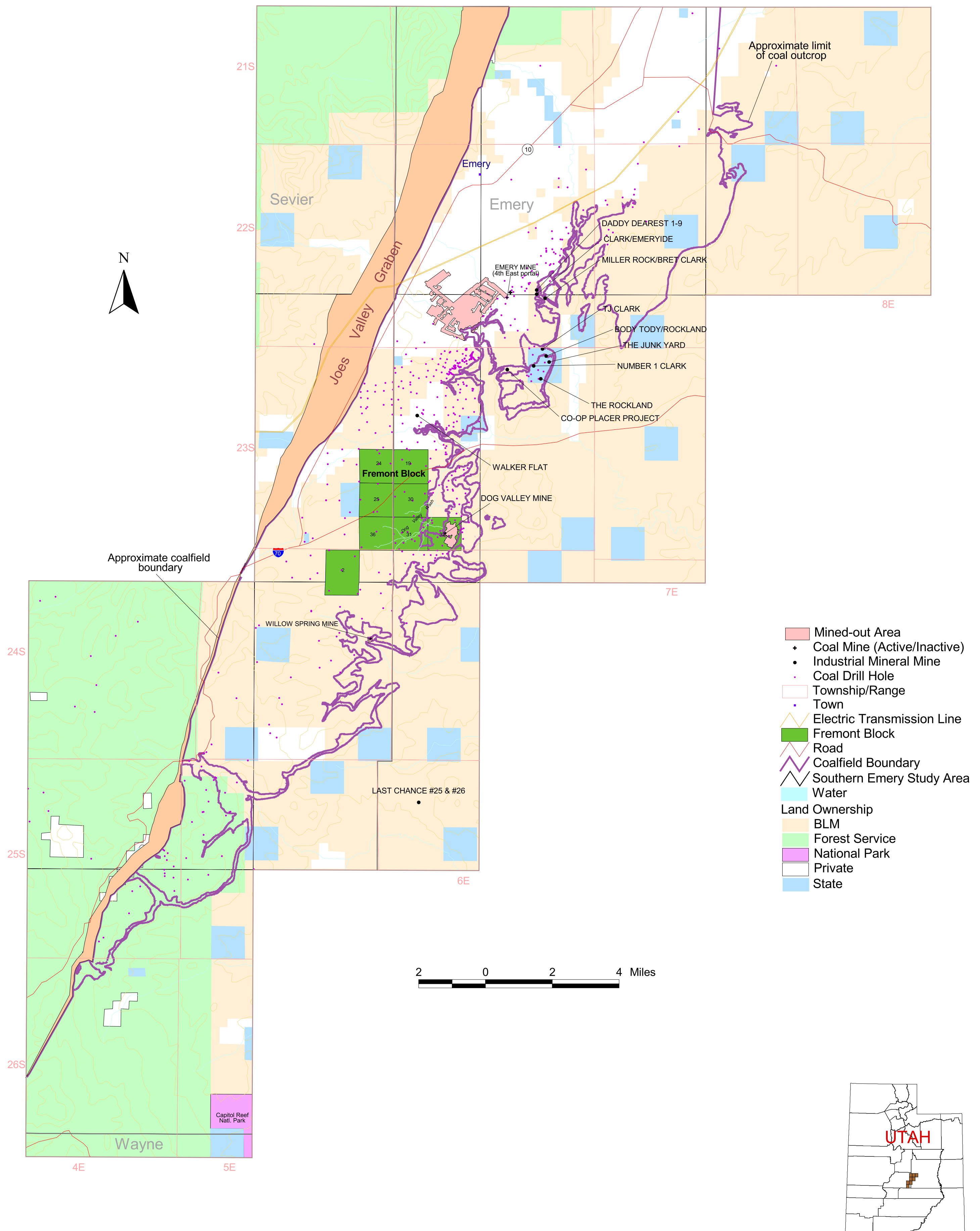


Plate 2. Location of the Fremont block within the southern Emery study area.

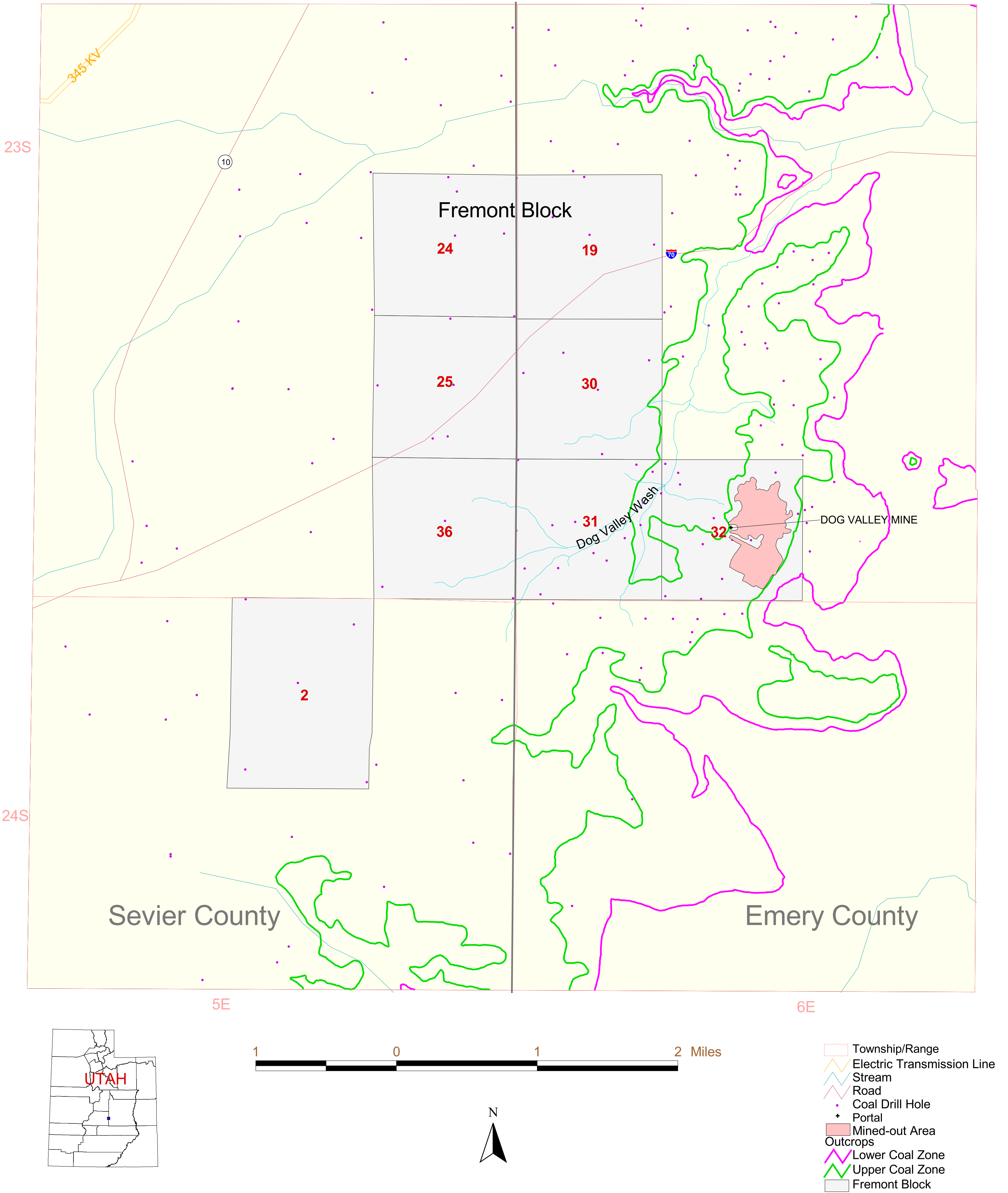


Plate 3. Location of coal outcrops, drill holes, and mined-out area of the Fremont block.

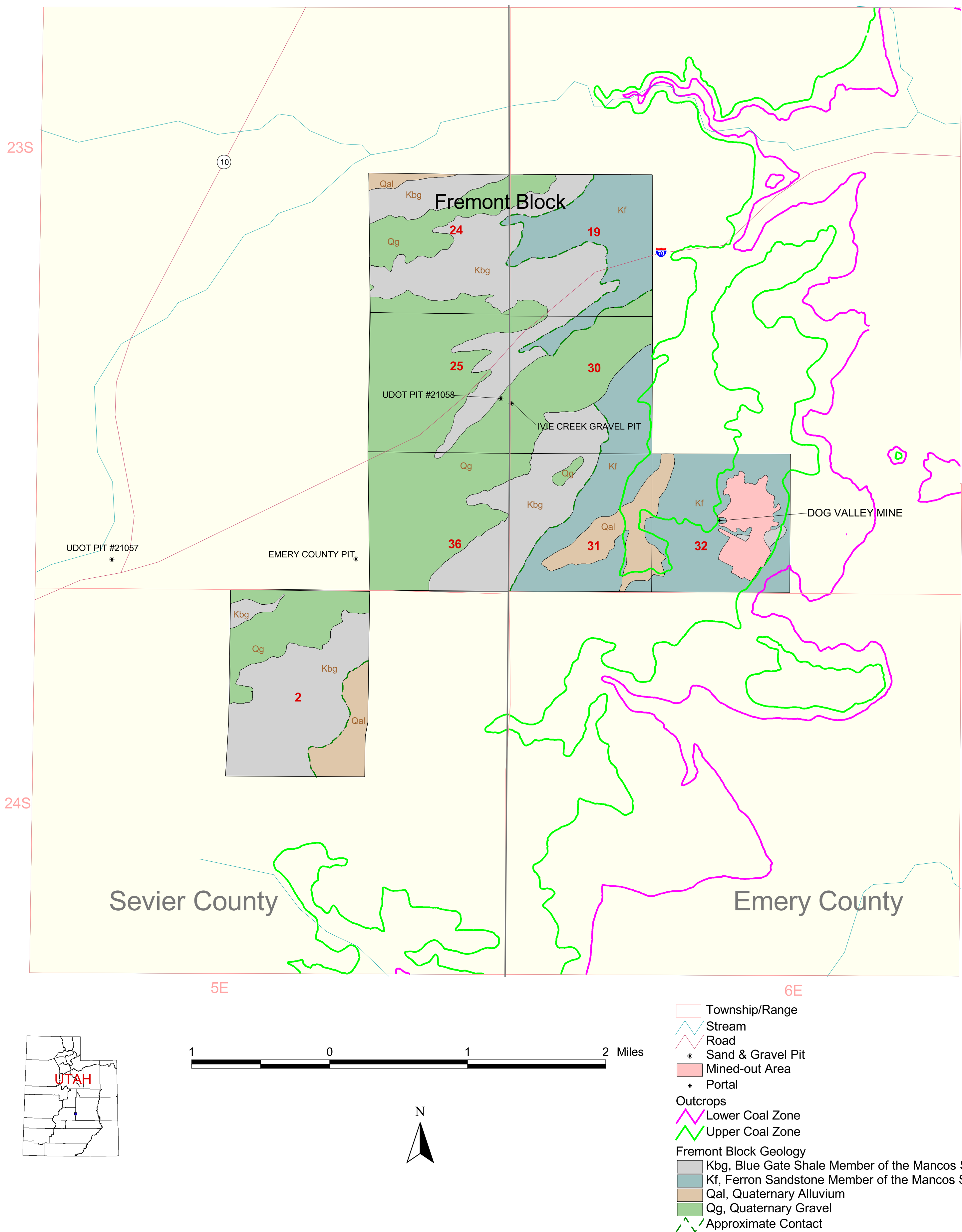


Plate 4. Surface geology of the Fremont block and the location of sand and gravel pits, coal outcrops, and the Dog Valley mine. (Data from Doelling, 1972)

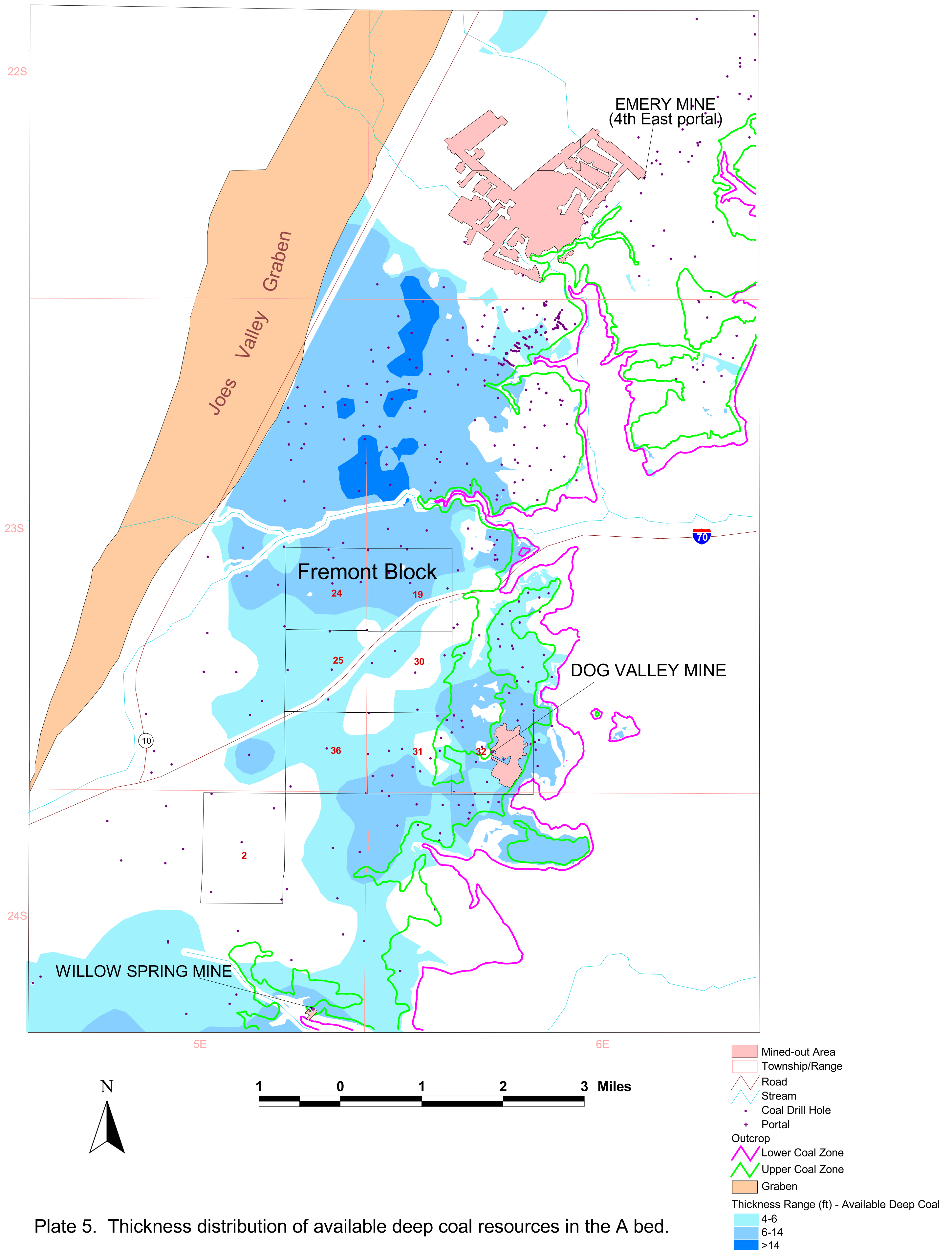


Plate 5. Thickness distribution of available deep coal resources in the A bed.

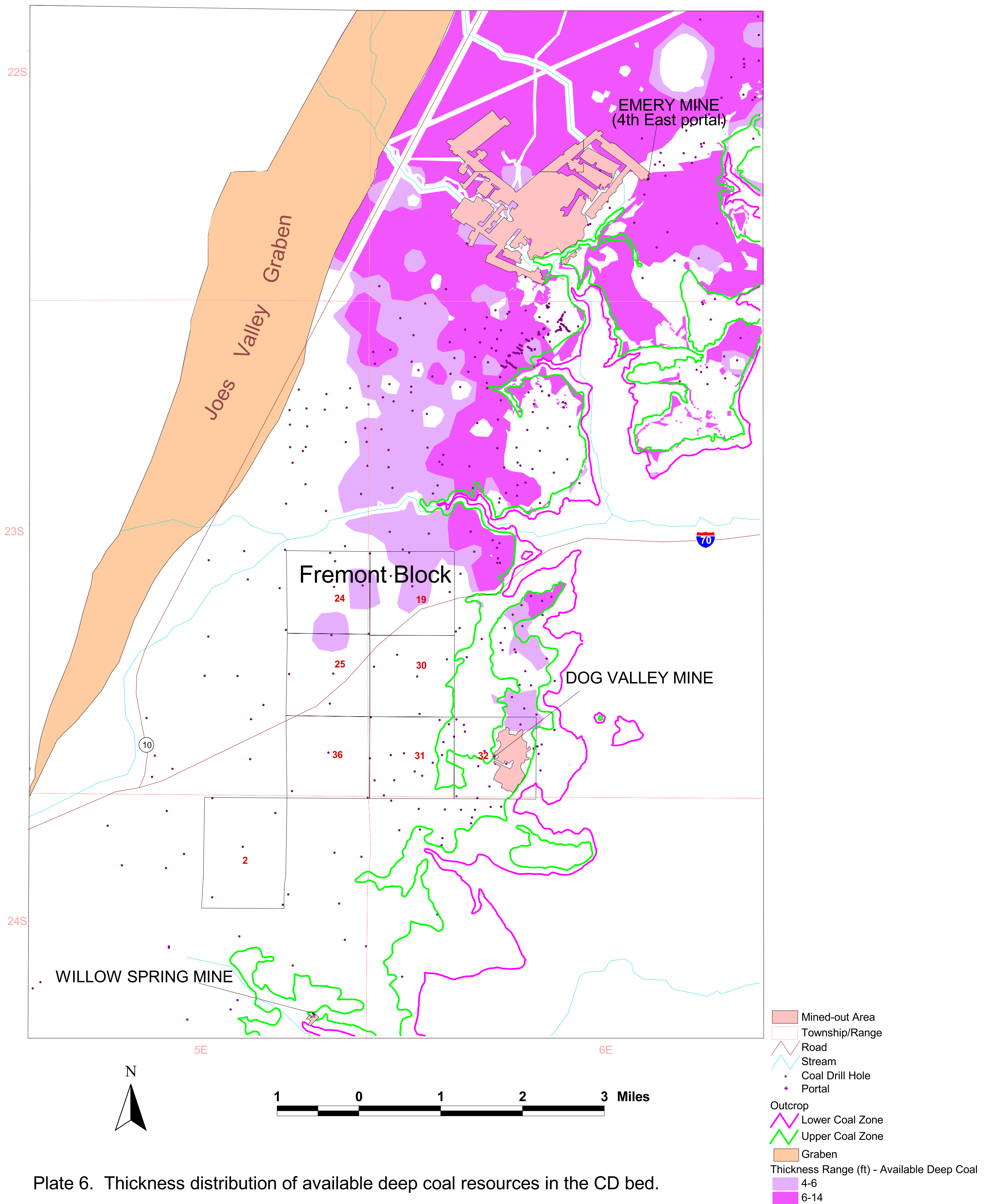


Plate 6. Thickness distribution of available deep coal resources in the CD bed.

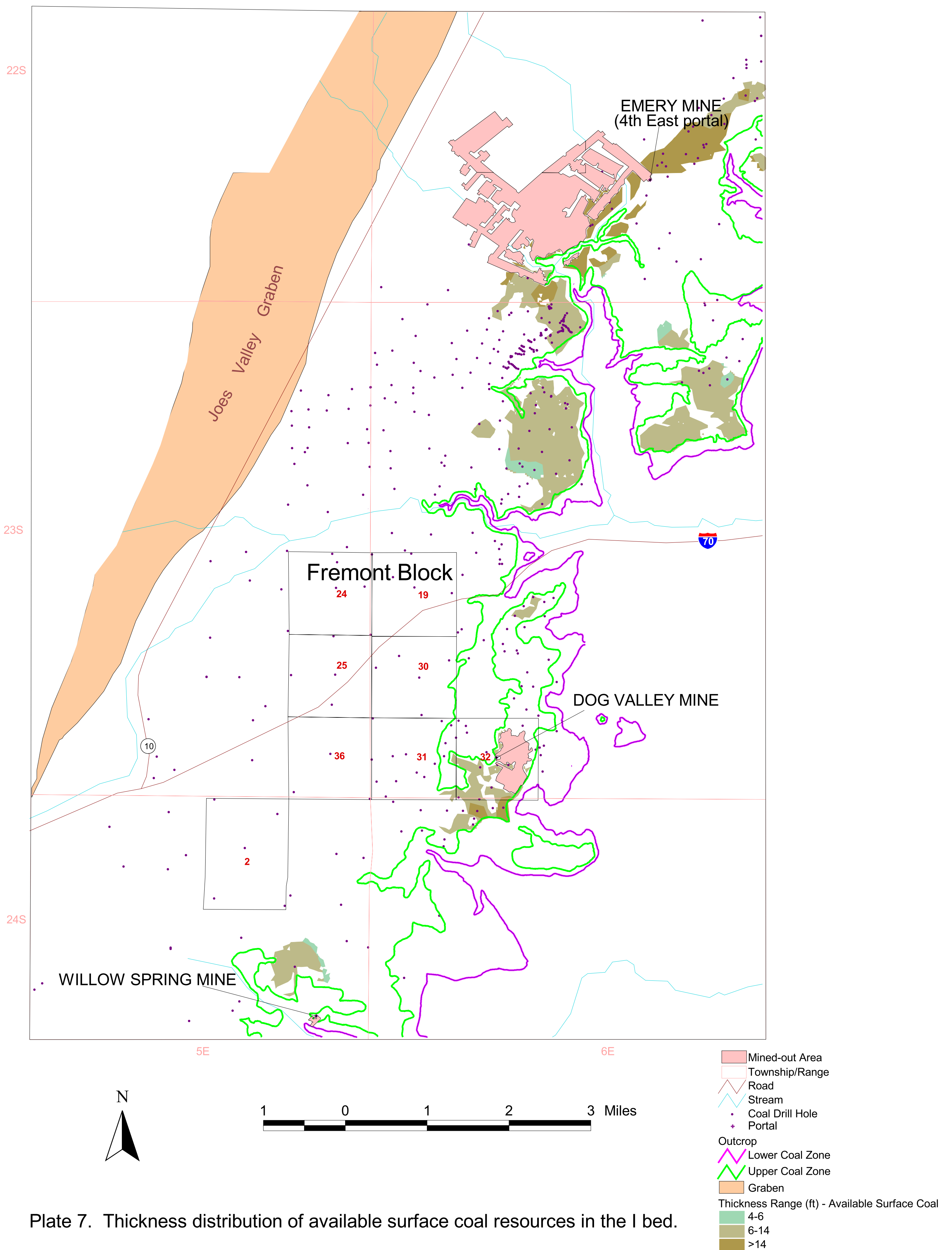


Plate 7. Thickness distribution of available surface coal resources in the I bed.

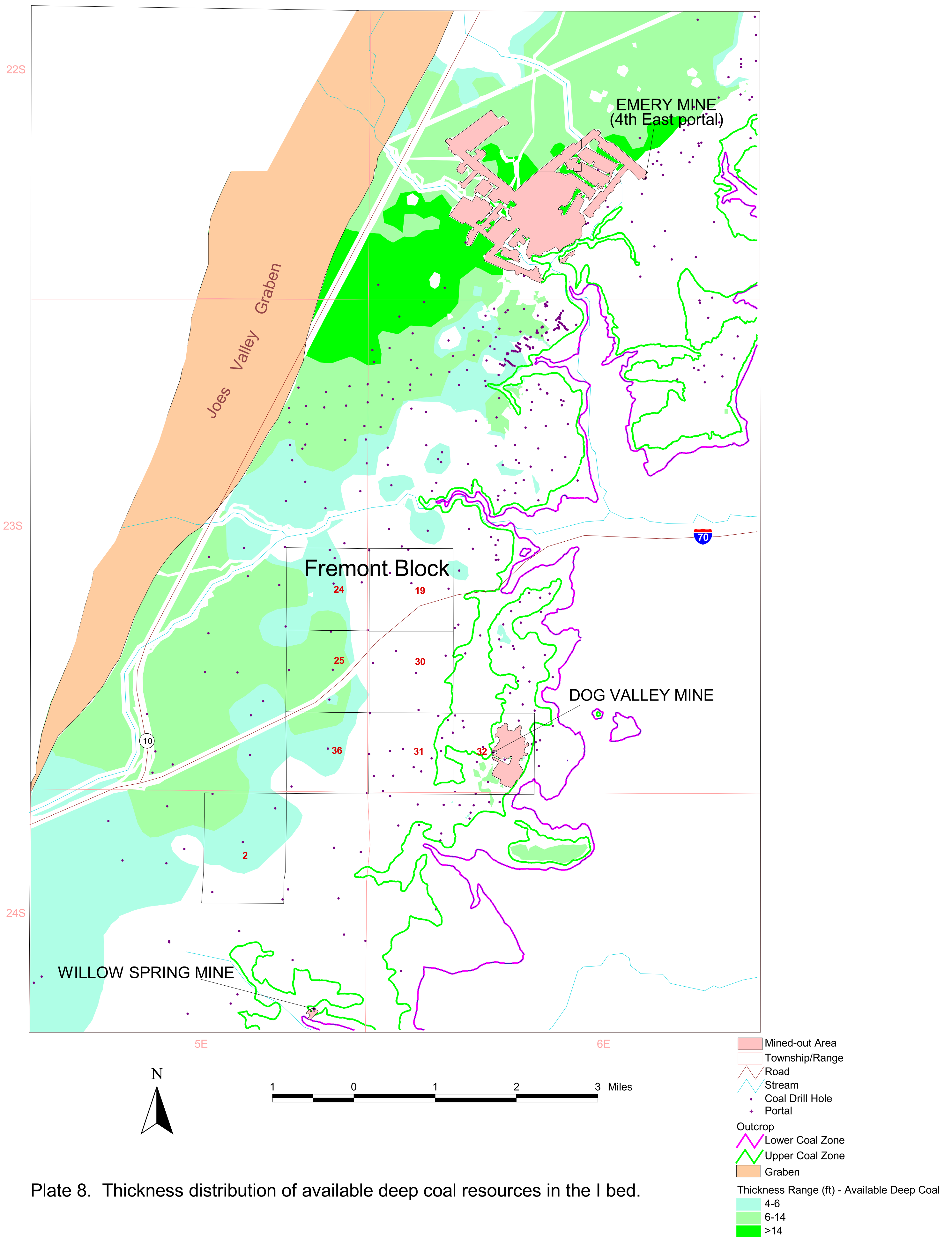


Plate 8. Thickness distribution of available deep coal resources in the I bed.

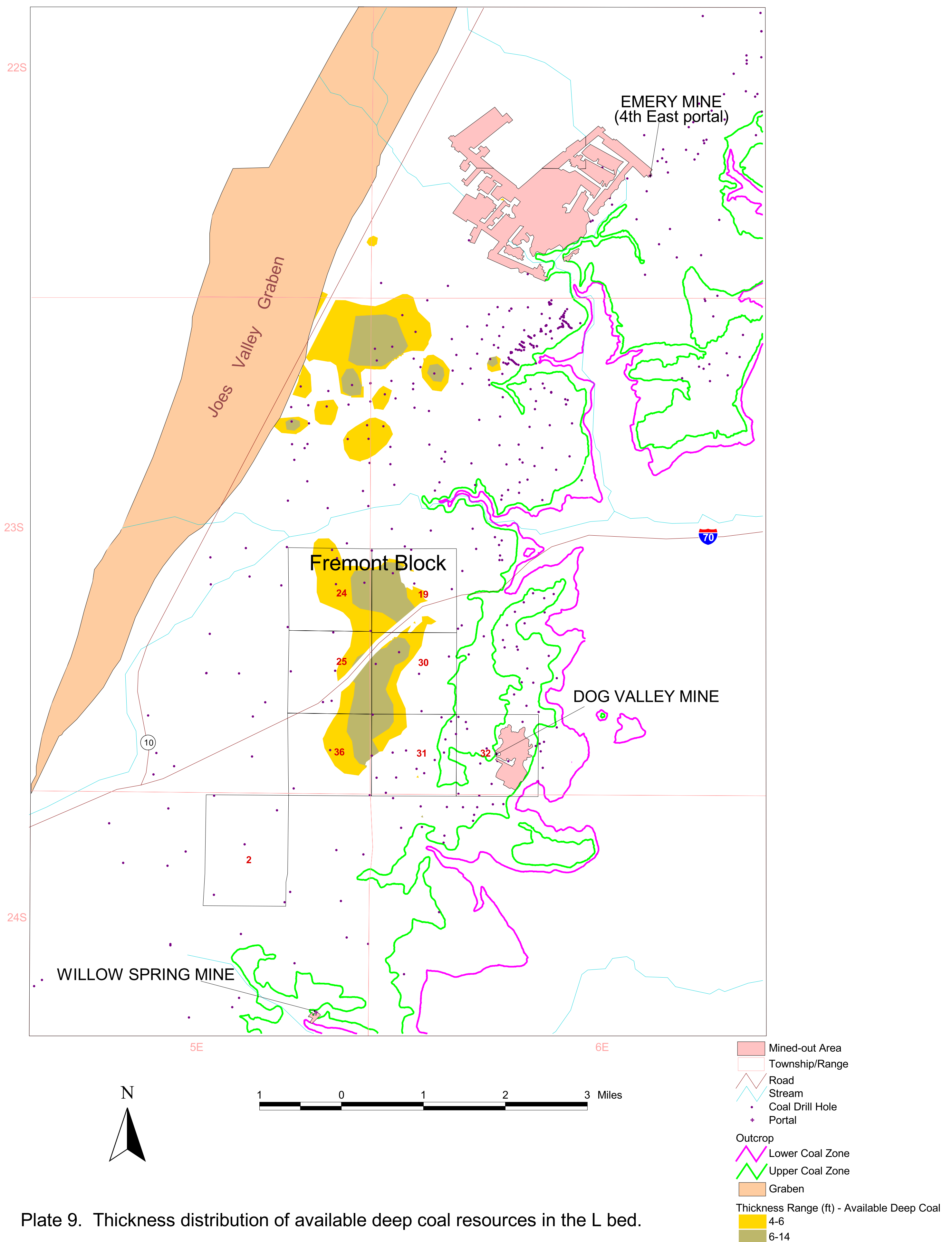


Plate 9. Thickness distribution of available deep coal resources in the L bed.

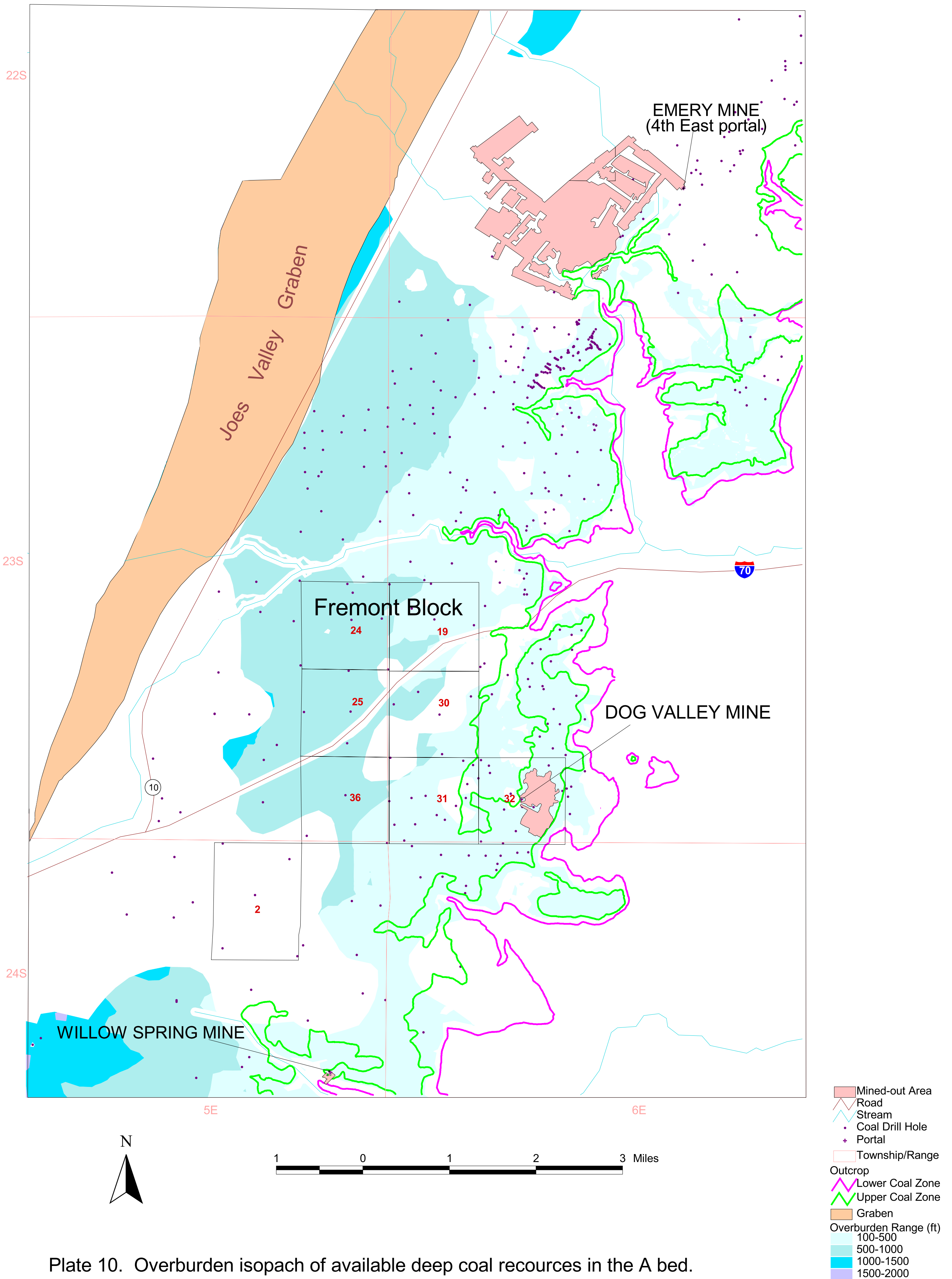


Plate 10. Overburden isopach of available deep coal resources in the A bed.

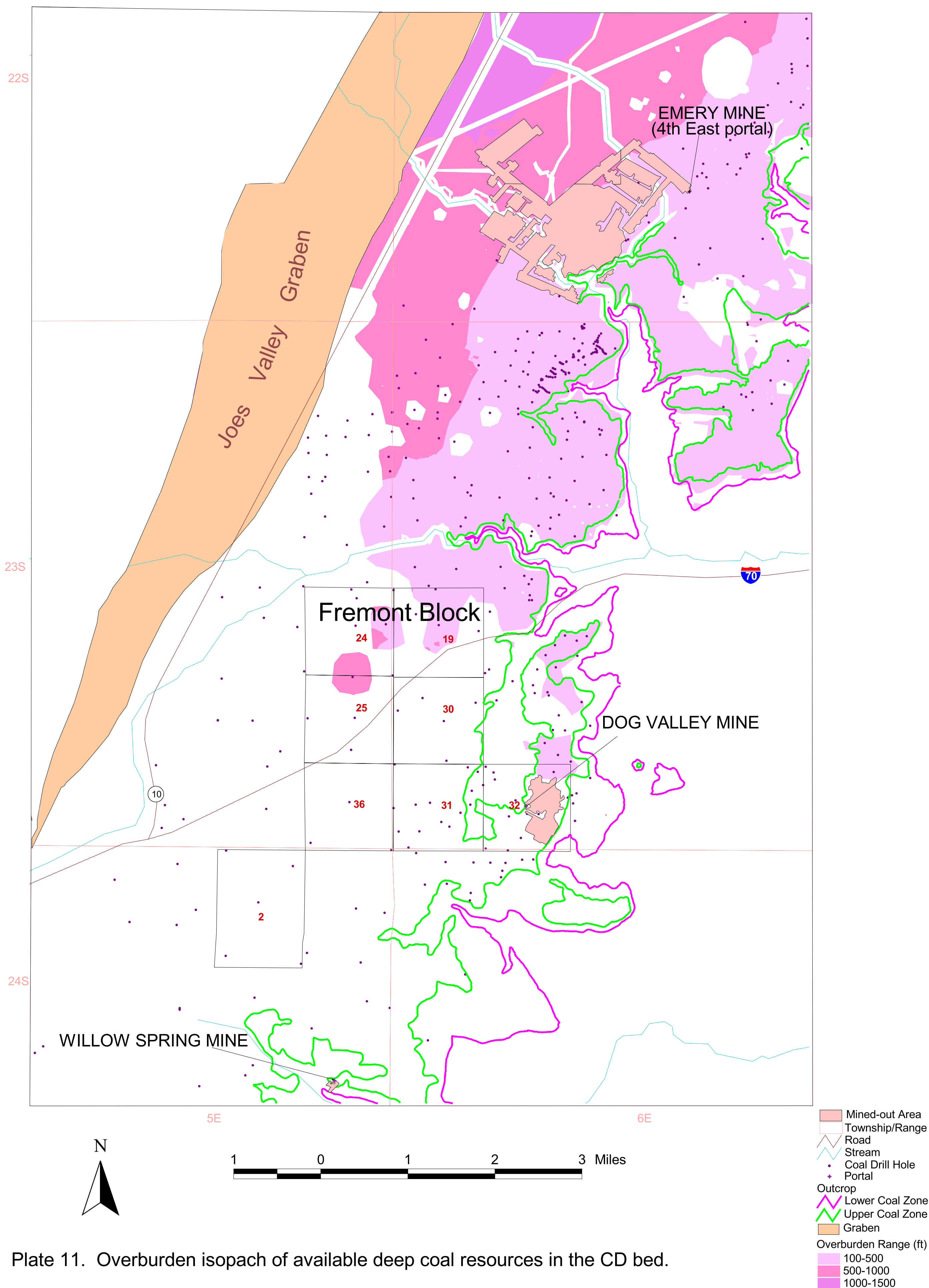


Plate 11. Overburden isopach of available deep coal resources in the CD bed.

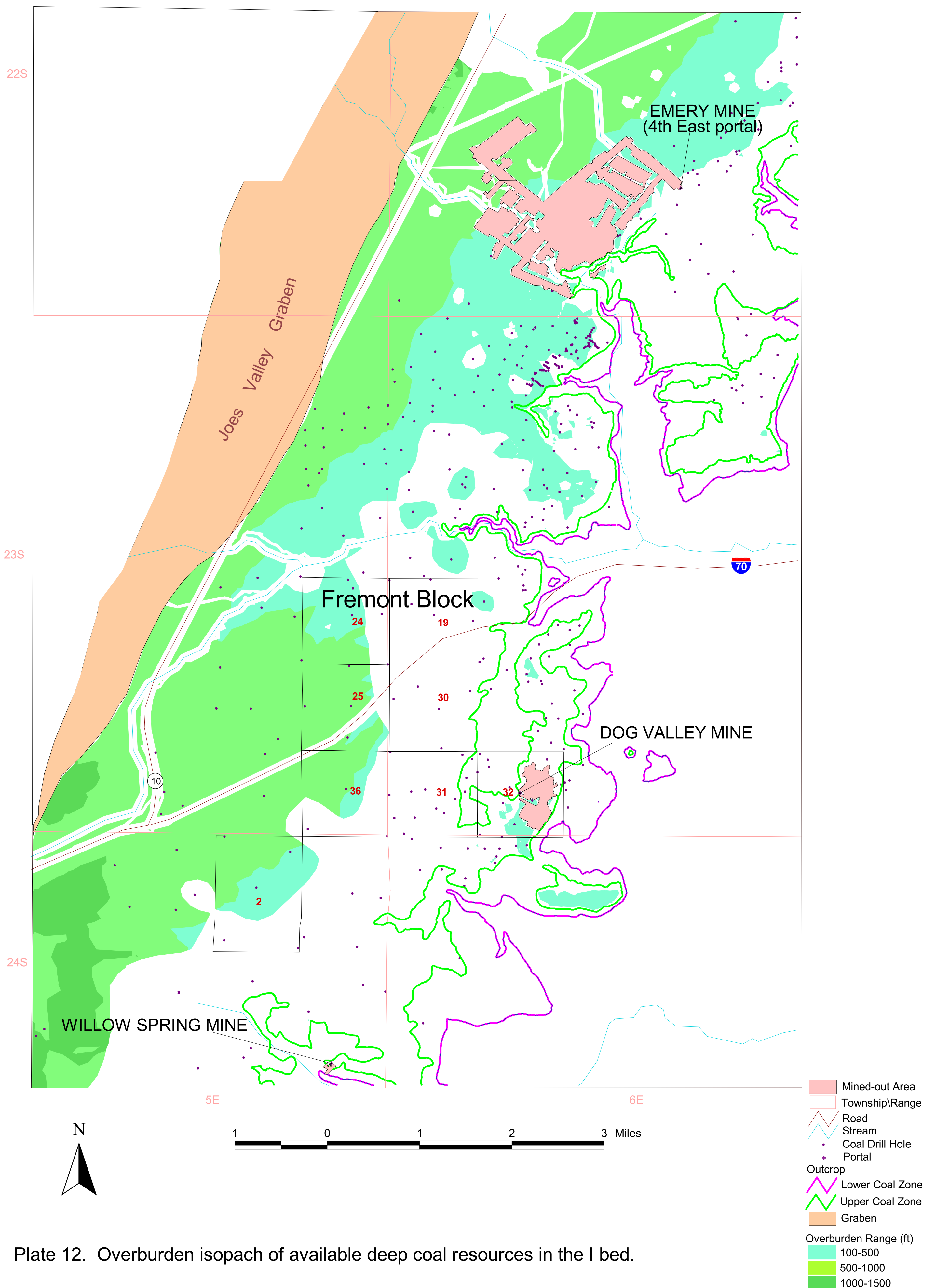


Plate 12. Overburden isopach of available deep coal resources in the I bed.

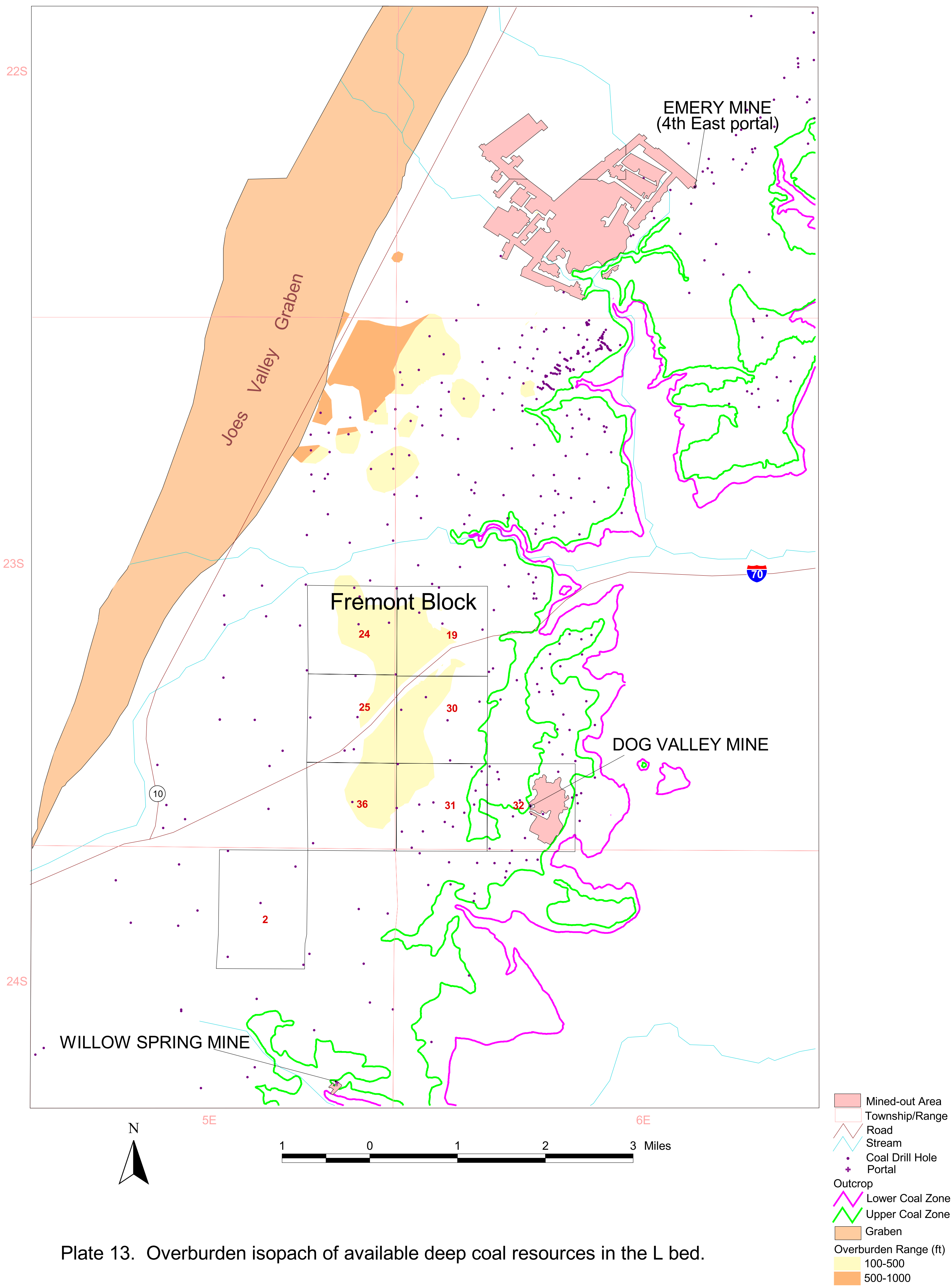


Plate 13. Overburden isopach of available deep coal resources in the L bed.